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FOR THE

Promotion of Engineering Education

PROCEEDINGS

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HELD IN

NIAGARA FALLS, N. Y., JULY 1–3, 1903

AND JOINT SESSION WITH

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Volume XI

EDITED BY

CALVIN M. WOODWARD C. FRANK ALLEN CLARENCE A. WALDO
Committee

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List of Members.

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Adams, Comfort A., Jr.... Cambridge, Mass	Assistant Professor of Electrical Engineering, Harvard University......	1894
Alderson, Victor C........ Golden, Colo.	President of Colorado School of Mines.	1900
Aldrich, William S....... Potsdam, N. Y.	Director, Clarkson School of Technology	1893
Allen, C. Frank......... Boston, Mass.	Professor of Railroad Engineering, Massachusetts Institute of Technology	1893
Allen, Charles M......... 8 Dean St., Worcester, Mass.	Assistant Professor of Experimental Engineering, Worcester Polytechnic Institute	1903
Anderson, F. Paul....... Lexington, Ky.	Dean of the School of Mechanical and Electrical Engineering, Professor of Mechanical Engineering, State College of Kentucky...............	1894
Anderson, Douglas S..... New Orleans, La.	Associate Professor of Electrical Engineering, Tulane University.........	1900
Anthony, Gardner C...... Tufts College, Mass.	Professor of Technical Drawing and Dean of the Department of Engineering, Tufts College.................	1896
Arnold, Bion J........... Chicago, Ill.	Consulting Electrical Engineer, 1539 Marquette Bldg..............	1896
Ayer, Arthur W.......... 35th St. and Gray's Ferry Road, Philadelphia, Pa.	Mechanical Engineer for Harrison Bros. and Co......................	1894
Ayers, Brown............ New Orleans, La.	Professor of Physics and Electrical Engineering, Dean of College of Technology, Tulane University......	1898
Baker, Ira O............. Champaign, Ill.	Professor of Civil Engineering, University of Illinois..............	1893

Name and Address.	Title.	Date of Membership.
Barney, Samuel E., Jr... New Haven, Conn.	Assistant Professor of Civil Engineering, Yale University..............	1894
Barr, John H............ Syracuse, N. Y.	Smith Premier Typewriter Company..	1902
Barraclough, S. Henry.. Sydney, N. S. W., Australia.	Lecturer on Mechanism and Applied Thermodynamics, Russell School of Engineering, University of Sydney..	1900
Barrows, Harold K...... 43 South Prospect St., Burlington, Vt.	Associate Professor of Civil Engineering, University of Vermont........	1902
Bates, Onward........... 320 Belden Ave., Chicago, Ill.	President of Bates and Rogers Construction Company.................	1903
Benjamin, Charles H.... Cleveland, Ohio.	Professor of Mechanical Engineering, Case School of Applied Science......	1893
Berg, Walter G.......... 261 West 52d St. New York City.	Chief Engineer, Lehigh Valley Railroad Co........................	1901
Beyer, Samuel W........ Ames, Iowa.	Professor of Geology and Mining Engineering, Iowa State College........	1899
Beyer, T. Raymond....... 119 Maplewood Ave., Germantown, Pa.	Civil Engineer.....................	1895
Bissell, George W....... Ames, Iowa.	Professor of Mechanical Engineering, Iowa State College................	1894
Bixby, Wm. H............ Jones Bldg., Detroit, Mich.	Major Corps of Engineers, U. S. Army, U. S. Engineer Office...............	1898
Blanchard, Arthur H.... Brown University, Providence, R. I.	Assistant Professor of Civil Engineering, Brown University............	1902
Boardman, Harold S..... Orono, Me.	Associate Professor of Civil Engineering, in Charge of Department, University of Maine...............	1903
Bovey, Henry T.......... Montreal, Que.	Dean of the Faculty of Applied Science, Professor of Civil Engineering and Applied Mechanics, McGill University	1893

Name and Address.	Title.	Date of Membership.
Bradford, Joseph N...... Columbus, Ohio.	Professor of Architecture and Drawing, Ohio State University.........	1896
Brady, Frank W......... Scranton, Pa.	Engineering Text-book Writer for the International Correspondence School.	1899
Bray, Charles D........ Tufts College, Mass.	Professor of Civil and Mechanical Engineering, Tufts College............	1894
Breckenridge, Lester P... Urbana, Ill.	Professor of Mechanical Engineering, University of Illinois..............	1893
Brill, George M.......... 1143–1144 Marquette B'lding, Chicago, Ill.	Consulting Engineer................	1894
Brooke, William E....... Minneapolis, Minn.	Instructor in Engineering Mathematics, University of Minnesota....	1902
Brooks, John P.......... Lexington, Ky.	Professor of Civil Engineering, State College of Kentucky..........	1898
Brooks, Morgan.......... Urbana, Ill.	Professor of Electrical Engineering, University of Illinois..............	1899
Brown, Harold W........ 21 Olive Street, Cleveland, O.	With Brown Hoisting Machine Co....	1902
Brown, J. Stanford....... 489 Fifth Ave., New York City.	New York Realty and Trust Co......	1903
Browne, Wm. Hand, Jr.... 431 Beech St., Richmond Hill, N. Y.	Technical Editor of the Electrical Review, New York..................	1899
Bruegel, A. Theodore..... 3728 Walnut St., Philadelphia, Pa.	Professor of Mechanical Engineering, Drexel Institute	1900
Brydone-Jack, Ernest E.. Fredericton, New Brunswick.	Dean of the Engineering Faculty, University of New Brunswick..........	1902
Bull, Storm............. Madison, Wis.	Professor of Steam Engineering, University of Wisconsin............	1893
Burgess, Charles F...... Madison, Wis.	Assistant Professor of Electrical Engineering, University of Wisconsin..	1896

Name and Address.	Title.	Date of Membership.
Burr, William H. New York, N. Y.	Professor of Civil Engineering, Columbia University	1893
Caldwell, Francis C. Columbus, Ohio.	Professor of Electrical Engineering, Ohio State University	1897
Carhart, Daniel, Wilkinsburg, Allegheny, Pa.	Professor of Civil Engineering and Dean of the Faculty, Western University of Pennsylvania	1902
Carpenter, Louis G. Fort Collins, Colo.	Professor of Civil and Irrigation Engineering, Director of Experiment Station, Colorado State Agricultural College	1895
Carpenter, Rolla C. Ithaca, N. Y.	Professor of Experimental Engineering, Cornell University	1893
Carson, William W. Knoxville, Tenn.	Professor of Civil Engineering, University of Tennessee	1894
Chandler, Clarence A. 12 Westland St., Worcester, Mass.	Superintendent of the Washburn Shops, Worcester Polytechnic Institute	1902
Chase, Charles H. 37 Lincoln St., Stoneham, Mass.	Assistant Professor of Steam Engineering, Tufts College	1900
Chatburn, George R. Lincoln, Neb.	Assistant Professor of Civil Engineering, University of Nebraska	1899
Christy, Samuel B. Berkeley, Cal.	Professor of Mining and Metallurgy, University of California	1893
Colburn, George L. Rochester, N. Y.	Instructor in Machine Work and Mechanical Drawing, Rochester Athaneum and Mechanics Institute	1901
Colby, Irving A. 119 Stewart Ave., Ithaca, N. Y.	Instructor in Wood Working, Cornell University	1902
Constant, Frank H. Minneapolis, Minn.	Professor of Structural Engineering, University of Minnesota	1896
Cooley, Mortimer E. Ann Arbor, Mich.	Professor of Mechanical Engineering, University of Michigan	1893
Corthell, Elmer L. 1 Nassau St., New York City.	Civil Engineer	1895

Name and Address.	Title.	Date of Membership.
Cox, Nelson H. Lake City, Fla.	Professor of Mechanical Engineering, Florida Agricultural College	1903
Crandall, Charles L. Ithaca, N. Y.	Professor of Railroad Engineering and Geodesy, Cornell University	1893
Creighton, W. H. P. New Orleans, La.	Professor of Mechanical Engineering, Tulane University	1893
Crenshaw, Bolling H. Auburn, Ala.	Associate Professor of Mathematics, Alabama Polytechnic Institute	1894
Cruikshank, Barton San Francisco, Cal.	President, Cogswell Polytechnic College	1999
Davis, Ellery W. Lincoln, Neb.	Dean of College of Literature, Science and the Arts, University of Nebraska.	1902
Dean, Arthur D. Springfield, Mass.	First Assistant, Mechanic Arts High School	1891
Denison, Charles S. Ann Arbor, Mich.	Professor of Stereotomy, Mechanism and Drawing, University of Michigan.	1893
Denton, James E. Hoboken, N. J.	Professor of Mechanical Engineering and Shopwork, Stevens Institute of Technology	1893
Denton, Frederick W. Houghton, Mich.	Superintendent, Winona Mine	1904
Diemer, Hugo Lawrence, Kans.	Associate Professor of Mechanical Engineering, University of Kansas	1902
Drane, Walter H. University, Miss.	Professor of Civil Engineering, University of Mississippi	1893
Drown, Thomas M. South Bethlehem, Pa.	President, Lehigh University	1895
Du Bois, A. Jay New Haven, Conn.	Professor of Civil Engineering, Yale University	1894
Dudley, Charles B. Altoona, Pa.	Chemist, Pennsylvania Railroad Company	1904
Duncan, Lindsay Boulder, Col.	Professor of Civil Engineering, University of Colorado	1891
Durand, William F. Ithaca, N. Y.	Professor of Marine Engineering, Cornell University	1899
Eddy, Henry T. Minneapolis, Minn.	Professor of Engineering and Mechanics, University of Minnesota	1893

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EMORY, FREDERICK L. Morgantown, W. Va.	Professor of Mechanics and Applied Mathematics, West Virginia University	1894
ENGLER, EDMUND A. Worcester, Mass.	President, Worcester Polytechnic Institute	1897
ESTERLINE, J. WALTER 401 State St., West La Fayette, Ind.	Assistant Professor of Electrical Engineering, Purdue University	1903
ESTY, WILLIAM South Bethlehem, Pa.	Professor of Electrical Engineering, Lehigh University	1898
FAIG, JOHN T. Lexington, Ky.	Professor of Machine Design, State College of Kentucky	1899
FARWELL, ELMER S. 309 Broadway, New York.	Consulting Engineer	1895
FERMIER, EMILE J. West La Fayette, Ind.	Instructor in Applied Mechanics, Purdue University	1903
FERNALD, ROBERT H. St. Louis, Mo.	Professor of Mechanical Engineering, Washington University	1899
FISHER, JAMES, JR. Houghton, Mich.	Instructor in Mathematics and Physics, Michigan College of Mines	1899
FLATHER, JOHN J. Minneapolis, Minn.	Professor of Mechanical Engineering, University of Minnesota	1893
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FLINT, WALTER Port Deposit, Md.	Supervising Engineer, The Jacob Tome Institute	1898
FORD, ARTHUR H. Atlanta, Ga.	Professor of Electrical Engineering, Georgia School of Technology	1903
FOSS, FRED. E. State College, Pa.	Professor of Civil Engineering, Pennsylvania State College	1893

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Fowler, Charles E....... 95 Gesler Way, Seattle, Wash.	President of Puget Sound Bridge and Dredging Co......................	1903
Foyé, Andrew E.......... 11 Broadway, New York City.	Vice-President of Standard Graphite Co.	1903
Frankforter, George B.... Minneapolis, Minn.	Professor of Chemistry, University of Minnesota...........	1897
Franklin, William S..... Bethlehem, Pa.	Professor of Physics, Lehigh University.................	1900
Freedman, William H.... 222 South Union St., Burlington, Vt.	Professor of Electrical Engineering, University of Vermont.	1902
French, Arthur W....... Worcester, Mass.	Professor of Civil Engineering, Worcester Polytechnic Institute.....	1900
French, Thomas E........ Columbus, O.	Associate Professor of Architecture and Drawing, Ohio State University.	1899
Frink, Fred. G........... Ann Arbor, Mich.	Instructor in Civil Engineering, University of Michigan................	1902
Fullan, M. Thomas J.... Auburn, Ala.	Assistant in Mechanical Engineering, Alabama Polytechnic Institute.....	1897
Fuller, Almon H......... University Station, Seattle, Wash.	Professor of Civil Engineering, University of Washington..........	1901
Galbraith, John.......... Toronto, Ont.	Principal and Professor of Engineering, School of Practical Science.....	1893
Ganz, Albert F........... Hoboken, N. J.	Professor of Electrical Engineering, Stevens Institute..................	1903
Giesecke, F. E............ College Station, Tex.	Professor of Drawing, Texas Agricultural and Mechanical College.......	1893
Gill, James H............ Bozeman, Mont.	Assistant Professor of Mechanical Practice, Montana College of Agriculture and Mechanic Arts............	1896
Gladson, William N..... Fayetteville, Ark.	Professor of Electrical Engineering, University of Arkansas............	1903

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
GOLDSBOROUGH, WINDER E.. Lafayette, Ind.	Professor of Electrical Engineering, Director of the Electrical Laboratory, Purdue University	1897
GOODENOUGH, GEORGE A.... Urbana, Ill.	Assistant Professor of Mechanical Engineering, University of Illinois....	1900
GOSS, WILLIAM F. M...... Lafayette, Ind.	Professor of Experimental Engineering and Dean of Schools of Engineering, Purdue University	1893
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GREENE, ARTHUR M., JR.... Columbia, Mo.	Professor of Mechanical Engineering, University of Missouri	1903
GRIFFIN, CHARLES L....... Syracuse, N. Y.		1900
GROAT, BENJAMIN F........ Minneapolis, Minn.	Assistant Professor of Mathematics and Mechanics, School of Mines, University of Minnesota	1899
GROVER, NATHAN C........ Orono, Me.	Engineer, U. S. Geological Survey....	1894
HALSTED, GEORGE B....... Annapolis, Md.	Professor of Mathematics, St. John's College	1899
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HANCOCK, EDWARD L....... La Fayette, Ind.	Instructor in Applied Mechanics, Purdue University	1903
HARRINGTON, JOHN LYLE... West New Brighton, N. Y.	Engineer, C. W. Hunt Co	1903
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HARRIS, ELMO G.......... Rolla, Mo.	Professor of Civil Engineering, School of Mines and Metallurgy, University of Missouri	1894

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Hasbrouck, Chas. A...... 1315 Monadnock Blk. Chicago, Ill	Contracting Manager of American Bridge Co., Western Division.......	1903
Hatt, William K........ Lafayette, Ind.	Professor of Applied Mechanics, Purdue University....................	1895
Haviland, Edwin, Jr..... Potsdam, N. Y.	Professor of Mathematics and Civil Engineering, Clarkson School of Technology	1902
Hawes, Joseph H......... Durham, N. H.	Associate Professor of Drawing, New Hampshire College of Agriculture and the Mechanic Arts........	1900
Haynes, Arthur E........ Minneapolis, Minn.	Professor of Engineering Mathematics, University of Minnesota............	1895
Hazen, John V........... Hanover, N. H.	Professor of Civil Engineering, Dartmouth College................	1896
Hedrick, Ira G........... 608 New Nelson Bldg., Kansas City, Mo.	Consulting Engineer................	1903
Heller, Albert H......... 1249 Niel Ave., Columbus, O.	Professor of Civil Engineering, Ohio State University..................	1903
Herget, Albert M......... 311 Convention St., Baton Rouge, La.	Professor of Drawing and Mechanic Arts, Louisiana State University...	1903
Hibbard, H. Wade........ Ithaca, N. Y.	Professor of Mechanical Engineering of Railways, Sibley College, Cornell University	1896
Hill, John E............ Providence, R. I.	Professor of Civil Engineering, Brown University.................	1894
Hitchcock, Embury A.... Columbus, Ohio.	Professor of Experimental Engineering, Ohio State University.........	1899
Hoag, William R........ Minneapolis, Minn.	Professor of Civil Engineering, University of Minnesota............	1893
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Name and Address.	Title.	Date of Membership.
Holden, Charles A., Hanover, N. H.	Instructor in Civil Engineering and Mathematics, Thayer School of Civil Engineering, Dartmouth College	1901
Hollis, Ira N., Cambridge, Mass.	Professor of Engineering, Harvard University	1894
Hood, Ozni P., Houghton, Mich.	Professor of Mechanical and Electrical Engineering, Michigan College of Mines	1893
Horton, George F., Throop and 105th Sts. Chicago, Ill.	Vice-President of Chicago Bridge and Iron Co.	1903
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Howe, Malverd A., Terre Haute, Ind.	Professor of Civil Engineering, Rose Polytechnic Institute	1894
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Jackson, Dugald C., Madison, Wis.	Professor of Electrical Engineering, University of Wisconsin	1893
Jackson, John P., State College, Pa.	Professor of Electrical Engineering, Pennsylvania State College	1894
Jacobus, D. S., Hoboken, N. J.	Professor of Experimental Mechanics and Engineering Physics, Stevens Institute of Technology	1893

Name and Address.	Title.	Date of Membership.
Jacoby, Henry S.......... Ithaca, N. Y.	Professor of Bridge Engineering and Graphics, Cornell University.......	1894
Jameson, Joseph M....... Brooklyn, N. Y.	Instructor in Physics, Pratt Institute	1903
Jenson, Joseph........... Logan, Utah.	Professor of Mechanical Engineering, State Agricultural College of Utah..	1903
Jett, Carter C........... 3200 West Ave., Newport News, Va.	Draughtsman Newport News Ship-building and Dry-dock Co..........	1902
Johnson, Lewis J........ Cambridge, Mass.	Assistant Professor of Civil Engineering, Lawrence Scientific School, Harvard University...............	1898
Jones, Clement R......... Morgantown, W. Va.	Professor of Mechanical Engineering, West Virginia University..........	1895
Jones, Forrest R......... Ithaca, N. Y.	Professor of Machine Design, Sibley College, Cornell University...	1893
Jones, Frederick S....... Minneapolis, Minn.	Professor of Physics and Dean of College of Engineering, University of Minnesota	1903
Kaup, William J......... Brooklyn, N. Y.	Instructor in Machine Construction, Pratt Institute....................	1903
Kavanaugh, William H.. Minneapolis, Minn.	Assistant Professor of Mechanical Engineering, in charge of Experimental Engineering, University of Minnesota	1902
Kay, Edgar B............ University, Ala.	Professor of Civil Engineering, University of Alabama...............	1898
Kenerson, William H.... 11 Hudson St., Providence, R. I.	Assistant Professor of Mechanical Engineering, Brown University........	1903
Kent, James M........... Kansas City, Mo.	Professor in Manual Training High School, of Kansas City.............	1903
Kent, William........... Syracuse, N. Y.	Dean of the College of Applied Science, Syracuse University..........	1894
Kenyon, Alfred M....... 103 Waldron St., West La Fayette, Ind.	Professor of Mathematics, Purdue University	1903

Name and Address.	Title.	Date of Membership.
Kerr, Charles V......... 3321 Armour Ave., Chicago, Ill.	Professor of Mechanical Engineering, Armour Institute of Technology....	1902
Ketchum, Milo S......... Kansas City, Mo.	With American Bridge Co...........	1903
Kinealy, J. H............ 1108 Pemberton Bldg., Boston, Mass.	Consulting Mechanical Engineer.....	1893
Kingsbury, Albert........ East Pittsburg, Pa.	Mechanical Engineer, with Westinghouse Electric and Manufacturing Co.	1893
Kinsley, Carl............ Quadrangle Club, Chicago, Ill.	Assistant Professor of Physics, University of Chicago................	1903
Knoch, Julius J.......... Fayetteville, Ark.	Professor of Civil Engineering, University of Arkansas.............	1898
Kyser, Henry H.......... Clemson College, S. C.	Assistant Professor of Electrical Engineering, Clemson Agricultural College	1897
Ladd, George E........... Rolla, Mo.	Director and Professor of Geology and Mining, School of Mines and Metallurgy	1901
Lambert, Preston A...... South Bethlehem, Pa.	Assistant Professor of Mathematics, Lehigh University.................	1897
Landreth, Olin H........ Schenectady, N. Y.	Professor of Civil Engineering, Union College.....................	1893
Lane, Henry M........... Rose Building, Cleveland, O.	Editor of the Foundry............	1900
Langsdorf, Alexander S.. St. Louis, Mo.	Assistant Professor of Electrical Engineering, Washington University...	1903
Lanphear, Burton S...... Ames, Iowa.	Assistant Professor of Electrical Engineering, Iowa State College......	1897
Lanza, Gaetano.. .... Boston, Mass.	Professor of Applied Mechanics, in charge of the Department of Mechanical Engineering, Massachusetts Institute of Technology..............	1893
La Rue, Benjamin F...... Scranton, Pa.	Principal School of Civil Engineering, International Correspondence Schools	1899

Name and Address.	Title.	Date of Membership.
Lawrence, James W...... Fort Collins, Colo.	Professor of Mechanical Engineering, State Agricultural College.........	1898
Love, Andrew C.......... College Station, Tex.	Assistant Professor of Drawing, Agricultural and Mechanical College of Texas	1900
Ludy, Llewellyn V...... 229 University St., West La Fayette, Ind.	Assistant Professor of Mechanical Engineering, Purdue University.......	1903
Lund, Robert L.......... 2102 Hays St., Nashville, Tenn.	Adjunct Professor of Civil Engineering, Vanderbilt University.........	1902
McCaustland, Elmer J... Ithaca, N. Y.	Assistant Professor of Mining and Surveying, Cornell University......	1902
McColl, Jay R........... La Fayette, Ind.	Associate Professor in Steam Engineering, Purdue University........	1894
McNair, Fred W......... Houghton, Mich.	President, Michigan College of Mines.	1897
Mack, John G. D......... 222 Jefferson St., Madison, Wis.	Professor of Machine Design, College of Engineering, University of Wisconsin.........................	1901
Macomber, Irwin J....... 422 Thirty-fourth St., Chicago, Ill.	Professor of Electrical Engineering, Armour Institute of Technology....	1902
Magowan, Charles S..... Iowa City, Iowa.	Professor of Municipal and Sanitary Engineering, State University of Iowa	1896
Magruder, William T.... Columbus, Ohio.	Professor of Mechanical Engineering, Ohio State University..............	1893
Maitland, Alexander, Jr. 1109 McGee St., Kansas City, Mo.	Contracting Manager of the American Bridge Co........................	1903
Mann, John L........... Hanover, N. H.	Associate Professor of Civil Engineering and Mechanical Drafting, Thayer School of Civil Engineering........	1902
Marburg, Edgar.......... Philadelphia, Pa.	Professor of Civil Engineering, University of Pennsylvania........	1894

Name and Address.	Title.	Date of Membership.
Marston, Anson......... Ames, Iowa.	Professor of Civil Engineering, Iowa State College..................	1894
Marvin, Frank O......... Lawrence, Kan.	Dean of the School of Engineering, Professor of Civil Engineering, University of Kansas..............	1893
Marx, Charles D......... Stanford University, Cal.	Professor of Civil Engineering, Leland Stanford Junior University..	1893
Mather, Thomas W....... Miami, Fla.		1894
Mathews, Hubert B...... Brookings, S. Dak.	Professor of Physics, South Dakota Agricultural College..	1896
Matthews, Charles P.... Lafayette, Ind.	Associate Professor of Electrical Engineering, Purdue University.......	1898
Maurer, Edward R....... Madison, Wis.	Professor of Mechanics, University of Wisconsin............	1897
Mead, Elwood............ Washington, D. C.	Professor of the Institutions and Practice of Irrigation, University of California; Expert in charge of Irrigation Investigations of the U. S. Department of Agriculture.........	1901
Meeker, Warren H....... Ames, Iowa.	Associate Professor of Mechanical Engineering, Iowa State College.......	1903
Mees, Carl L............ Terre Haute, Ind.	President, Rose Polytechnic Institute..........	1894
Mendenhall, Thomas C... Worcester, Mass.		1895
Merriman, Mansfield..... South Bethlehem, Pa.	Professor of Civil Engineering, Lehigh University.................	1893
Miggett, William L...... 331 Jefferson St., Ann Arbor, Mich.	Superintendent of the Engineering Shops, University of Michigan.....	1902
Moran, Daniel E......... 35 Nassau St., New York City.	Secretary and Engineer of Foundation and Contracting Co., New York City	1903
Moore, Stanley H........ Kansas City, Mo.	Director Manual Training Department, Manual Training High School......	1902

Name and Address.	Title.	Date of Membership.
More, Charles C. Port Townsend, Wash.	U. S. Engineer's Office	1901
Morley, Frederick. Lapeer, Mich.	Res. Engr. St. Clair Flats Survey for the State of Michigan	1896
Munroe, Henry S. New York, N. Y.	Professor of Mining, Columbia University	1893
Nagle, James C. College Station, Tex.	Professor of Civil Engineering, Agricultural and Mechanical College of Texas	1897
Neff, Frank H. Cleveland, Ohio.	Professor of Civil Engineering, Case School of Applied Science	1895
Nesbit, Arthur F. Durham, N. H.	Associate Professor of Physics and Electrical Engineering, New Hampshire College of Agriculture and Mechanic Arts	1902
Norris, Henry H. Ithaca, N. Y.	Assistant Professor of Electrical Engineering and Electrician to the Department of Light, Heat and Power, Cornell University	1900
Ordway, John M. New Orleans, La.	Professor of Biology, A. T. Newcomb College	1894
Orton, Edward, Jr. Columbus, Ohio.	Dean of College of Engineering, Director of the Department of Clay Working and Ceramics, State Geologist of Ohio, Ohio State University	1900
Ostrander, John E. Amherst, Mass.	Professor of Mathematics and Civil Engineering, Massachusetts Agricultural College	1894
Owens, Robert B. Montreal, Que.	Professor of Electrical Engineering, McGill University	1894
Palmer, Chas. S. Golden, Col.		1903
Palmer, Walter K. 401 N. Y. Life Bldg., Kansas City, Mo.	Consulting Mechanical and Electrical Engineer	1899
Park, Charles F. 62 Summer St., Taunton, Mass.	Assistant Professor of Mechanical Engineering, Massachusetts Institute of Technology	1903

Name and Address.	Title.	Date of Membership.
Pence, William D. Lafayette, Ind.	Professor of Civil Engineering, Purdue University	1895
Pettee, Charles H. Durham, N. H.	Professor of Mathematics, New Hampshire College	1898
Phetteplace, Thurston M. 1612 Broad St., Providence, R. I.	Instructor in Mechanical Engineering, Brown University	1903
Phillips, James D. Madison, Wis.	Assistant Professor of Engineering Drawing, University of Wisconsin	1899
Porter, Dwight Boston, Mass.	Professor of Hydraulic Engineering, Massachusetts Institute of Technology	1893
Porter, J. Madison Easton, Pa.	Professor of Civil Engineering, Lafayette College	1893
Powell, Emery H. 1538 Madison Ave., Scranton, Pa.	Engineering Text-book Writer, International Correspondence School	1903
Price, Melvin Lincoln, Neb.	Instructor in Mechanical Drawing and Machine Design, University of Nebraska	1900
Puffer, William L. Boston, Mass.	Associate Professor of Electrical Engineering, Massachusetts Institute of Technology	1903
Pupin, Michael I. New York, N. Y.	Professor of Electro-mechanics, Columbia University	1895
Puryear, Charles College Station, Tex.	Professor of Mathematics, Agricultural and Mechanical College of Texas	1901
Randall, Otis E. Providence, R. I.	Professor of Mechanical Drawing, Brown University	1903
Randolph, Lingan S. Blacksburg, Va.	Professor of Mechanical Engineering, Virginia Polytechnic Institute	1894
Raymond, William G. Troy, N. Y.	Professor of Geodesy and Road Engineering, Rensselaer Polytechnic Institute	1893
Reber, Louis E. State College, Pa.	Dean of School of Engineering, Professor of Mechanical Engineering, The Pennsylvania State College	1893

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
REYNOLDS, HERMAN W..... Agricultural College, Mich.	Assistant Professor of Mechanical Engineering, Michigan Agricultural College	1903
RICHARDS, CHARLES R...... Lincoln, Neb.	Professor of Mechanical Engineering and Director of the School of Mechanic Arts, University of Nebraska.	1895
RICHARDS, ROBERT H...... Boston, Mass.	Professor of Mining Engineering and Metallurgy, Massachusetts Institute of Technology.....................	1895
RICHARDSON, JAMES P..... 3918 Wyandotte St., Kansas City, Mo.	Prosso School......................	1903
RICHTER, ARTHUR W....... Madison, Wis.	Professor of Experimental Engineering, University of Wisconsin.......	1894
RICKER, N. CLIFFORD....... Urbana, Ill.	Dean of College of Engineering, University of Illinois..............	1894
RIGGS, WALTER M......... Clemson College, S. C.	Professor of Electrical Engineering, and Director of the Mechanical Department, Agricultural and Mechanical College of South Carolina......	1897
ROBBINS, ARTHUR G........ Boston, Mass.	Assistant Professor of Highway Engineering, Massachusetts Institute of Technology	1894
ROBERTS, WILLIAM J....... Pullman, Wash.	Associate Professor of Mathematics and Civil Engineering, Washington Agricultural College and School of Science	1903
ROBINSON, EDWARD........ Burlington, Vt.	Professor of Mechanical Engineering, University of Vermont............	1899
ROBINSON, FREDERIC H..... Newark, Del.	Professor of Civil Engineering, Delaware College.................	1894
ROBINSON, STILLMAN W.... Columbus, Ohio.	Mechanical Engineer and Expert, 1353 Highland St................	1893
RONDINELLA, LINO F....... 728 Stephen Girard Bldg., Philadelphia, Pa.	Professor of Constructive Drawing, Central Manual Training School of Philadelphia	1903

Name and Address.	Title.	Date of Membership.
Rosebrugh, Thomas R.... Toronto, Ontario.	Professor of Electrical Engineering, School of Practical Science.........	1896
Rowe, George H.......... Stanford University. Cal.	Professor of Electrical Engineering, Leland Stanford Junior University.	1903
Rowland, Arthur J....... 4510 Osage Ave., Philadelphia, Pa.	Professor of Electrical Engineering, Drexel Institute..................	1903
Russell, Walter B....... Brooklyn N. Y.	Assistant Instructor in Steam and Mechanical Laboratory, Pratt Institute.	1903
Ryan, Harris J........... 114 Cascadilla Place, Ithaca, N. Y.	Professor of Electrical Engineering, Sibley College, Cornell University..	1901
Sanborn, Frank E........ Columbus, O.	Director Industrial Arts Department, Secretary of the College of Engineering, Ohio State University..........	1899
Schmidt, Edward C....... St. Paul, Minn.	Assistant Engineer, American Hoist and Derrick Company............	1899
Schneider, Herman....... Cincinnati, O.	Instructor in Civil Engineering, University of Cincinnati..........	1903
Schuerman, William H... Nashville, Tenn.	Dean of the Engineering Department, Professor of Civil Engineering, Vanderbilt University................	1895
Scott, Arthur C......... Austin, Texas.	Professor of Electrical Engineering, University of Texas..............	1903
Sedgwick, William T..... Boston, Mass.	Professor of Biology, Massachusetts Institute of Technology............	1896
Sever, George F........... New York, N. Y.	Adjunct Professor of Electrical Engineering, Columbia University.....	1903
Sheldon, Samuel .... Brooklyn, N. Y.	Professor of Physics and Electrical Engineering, Polytechnic Institute of Brooklyn	1903
Shepardson, George D..... Minneapolis, Minn.	Professor of Electrical Engineering, University of Minnesota...........	1895

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
SHORT, ROBERT L.......... Chicago, Ill.	With D. C. Health & Co............	1902
SLOCUM, ROY H........... Urbana, Ill.	Instructor in Theoretical and Applied Mechanics, University of Illinois....	1903
SMITH, ALTON L.......... Worcester, Mass.	Assistant Professor of Drawing and Machine Design, Worcester Polytechnic Institute......................	1902
SMITH, HAROLD B.......... Worcester, Mass.	Professor of Electrical Engineering, Worcester Polytechnic Institute....	1898
SMITH, HARRY E.......... Brooklyn, N. Y.	Assistant Professor of Mechanical Engineering, Pratt Institute..........	1895
SMITH, HERBERT S. S...... Princeton, N. J.	Professor of Applied Mechanics, Princeton University..............	1894
SMITH, LEONARD S........ 938 University Ave., Madison, Wis.	Assistant Professor of Topographic and Geodetic Engineering, University of Wisconsin	1903
SNOW, CHARLES H......... New York, N. Y.	Dean of School of Applied Science, New York University..............	1895
SNOW, WALTER B......... 29 Russel Ave., Watertown, Mass.	Mechanical Engineer, B. F. Sturtevant Co., Jamaica Plain, Mass..........	1899
SOLBERG, HALVOR C......... Brookings, S. D.	Professor of Mechanical Engineering, South Dakota Agricultural College..	1894
SPALDING, FREDERICK P.... Columbia, Mo.	Professor of Civil Engineering, University of State of Missouri.....	189
SPANGLER, HENRY W...... Philadelphia, Pa.	Professor of Mechanical Engineering, University of Pennsylvania.........	1893
SPERR, FREDERICK W....... Houghton, Mich.	Professor of Civil and Mining Engineering, Michigan College of Mines..	1896
SPINNEY, LOUIS B......... Ames, Iowa.	Professor of Physics and Electrical Engineering, Iowa State College....	1899
SPRINGER, FRANK W., Minneapolis, Minn.	Assistant Professor of Electrical Engineering, University of Minnesota..	1896

Name and Address.	Title.	Date of Membership.
Stanwood, James B....... Cincinnati, Ohio.	Director, Technical School of Cincinnati......	1894
Stewart, Clinton B...... Anchor, Ill.	Civil Engineer.....................	1894
Stewart, Louis B......... Toronto, Ontario.	Lecturer in Surveying, School of Practical Science.........	1897
Stout, Oscar Van P...... Lincoln, Neb.	Professor of Civil Engineering, University of Nebraska................	1894
Stubbs, Joseph E......... Reno, Nev.	President, Nevada State University...........	1897
Swain, George F.......... Boston, Mass.	Professor of Civil Engineering, Massachusetts Institute of Technology....	1893
Swift, Walter........... Sheffield, England.	Secretary of Technical Department, University College.................	1902
Talbot, Arthur N........ Urbana, Ill.	Professor of Municipal and Sanitary Engineering, University of Illinois..	1893
Talbot, Henry P......... Boston, Mass.	Professor of Analytical Chemistry, Massachusetts Institute of Technology	1902
Taylor, Thomas U........ Austin, Texas.	Professor of Civil Engineering, University of Texas..................	1902
Taylor, William D....... 415 Wisconsin Ave., Madison, Wis.	Professor of Railway Engineering, University of Wisconsin............	1894
Thaler, Joseph A......... Bozeman, Mont.	Professor of Electrical Engineering, Montana College of Agriculture and Mechanic Arts....................	1901
Thomas, Robert G......... Charleston, S. C.	Professor of Mathematics and Engineering, South Carolina Military Academy...	1894
Thornburg, Charles L.... South Bethlehem, Pa.	Professor of Mathematics and Astronomy, Lehigh University............	1894
*Thurston, Robert H..... Ithaca, N. Y.	Director of Sibley College, Cornell University................	1893
Timmerman, Arthur H.... St. Louis, Mo.	Superintendent Wagner Electric Mfg. Co.	1894

* Died October 25, 1903.

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
TITSWORTH, ALFRED A..... 590 George St., New Brunswick, N. J.	Professor of Graphics and Mathematics, Rutgers College................	1903
TOWLE, WILLIAM M........ Syracuse, N. Y.	Associate Professor of Practical Mechanics, Smith College, Syracuse University	1895
TURNEAURE, FREDERICK E.. Madison, Wis.	Professor of Bridge and Sanitary Engineering, University of Wisconsin..	1894
TURNER, DANIEL L........ Cambridge, Mass.	Instructor in Surveying and Hydraulics, Lawrence Scientific School, Harvard University................	1898
TURNER, WILLIAM P....... Lafayette, Ind.	Assistant Professor of Practical Mechanics, Purdue University.........	1900
TURRILL, SHERMAN M...... 114 Willoughby St., Brooklyn, N. Y.	Civil Engineer......................	1903
TYLER, HARRY W.......... 419 Boylston St., Boston, Mass.	Professor of Mathematics, and Secretary, Massachusetts Institute of Technology	1894
VAN ORNUM, J. L.......... St. Louis, Mo.	Professor of Civil Engineering, Washington University............	1895
VEDDER, HERMAN K....... Agricultural College, Mich.	Professor of Mathematics and Civil Engineering, Michigan State Agricultural College.	1894
VOTEY, J. WILLIAM........ Burlington, Vt.	Professor of Civil Engineering, University of Vermont................	1902
VOSSKUEHLER, JOSEPH H.. Columbus, Ohio.	Instructor in Drawing, Ohio State University	1902
WADDELL, J. A. L.......... Kansas City, Mo.	Consulting Bridge Engineer, of Waddell and Hedrick..................	1893
WADSWORTH, JOEL E...... 22 Marsemere Place, Yonkers, N. Y.	Assistant Chief Engineer, Operating and Engineering Department, Eastern Division, American Bridge Co...	1895
WADSWORTH, M. EDWARD... State College, Pa.	Professor of Mining and Geology, Pennsylvania State College........	1895
WALDO, CLARENCE A....... Lafayette, Ind.	Head Professor of Mathematics, Purdue University.................	1897

Name and Address.	Title.	Date of Membership.
Walker, Elton D. State College, Pa.	Professor of Hydraulic and Sanitary Engineering, The Pennsylvania State College	1895
Wallace, John F. 4427 Greenwood Ave., Chicago, Ill.	General Manager, Illinois Central Railroad Co.	1903
Webb, Howard S. Orono, Me.	Professor of Electrical Engineering, University of Maine	1897
Weld, Laenas G. 612 North Dubuque St., Iowa City, Ia.	Professor of Mathematics and Dean of Graduate College, State University of Iowa; State Superintendent of Weights and Measures for Iowa	1903
Whipple, George C. Brooklyn, N. Y.	Director of Mt. Prospect Laboratory, Flatbush Ave. and Eastern Parkway.	1896
White, James McLaren. Champaign, Ill.	Professor of Architectural Engineering, University of Illinois	1900
Whitney, Willis R. Boston, Mass.	Assistant Professor of Theoretical Chemistry, Massachusetts Institute of Technology, Boston, Mass., Director of Research Laboratory of the General Electric Company, Schenectady, N. Y.	1902
Willett, James R. 434 Jackson Boulevard, Chicago, Ill.	Architect	1896
Williams, Frank B. 12 Gillespie Street, Schenectady, N. Y.	Associate Professor of Engineering, Union College	1901
Williams, Sylvester N. Mt. Vernon, Iowa.	Professor of Civil Engineering, Cornell College	1893
Williston, Arthur L. Brooklyn, N. Y.	Director Department of Science and Technology, Pratt Institute	1897
Wilmore, John J. Auburn, Ala.	Professor of Mechanical Engineering, Alabama Polytechnic Institute	1894
Wilson, Victor T. Ithaca, N. Y.	Instructor in Freehand and Mechanical Drawing, Cornell University	1898

Name and Address.	Title.	Date of Membership.
Wing, Charles B......... Stanford University, California.	Professor of Structural Engineering, Leland Stanford Junior University..	1895
Wood, Arthur J......... Newark, Del.	Professor of Mechanical and Electrical Engineering, Delaware College.	1898
Woodward, Calvin M..... St. Louis, Mo.	Dean of the School of Engineering and Architecture, Washington University	1894
Woodward, Robert S...... New York, N. Y.	Professor of Mechanics and Mathematical Physics, Columbia University	1893
Young, Lewis E.......... Ames, Ia.	Assistant Professor of Mining Engineering, Iowa State College.......	1903
Zimmerman, Oliver B..... 222 Charter St., Madison, Wis.	Assistant Professor of Machine Design, University of Wisconsin.......	1902
Ziwet, Alexander........ Ann Arbor, Mich.	Professor of Mathematics, University of Michigan............	1897

GEOGRAPHICAL DISTRIBUTION OF MEMBERS.

Alabama.—Crenshaw, Fullan, Kay, Wilmore.

Arkansas.—Gladson, Knoch.

California.—Christy, Cruikshank, Hoskins, Marx, Rowe, Wing.

Colorado.—Alderson, L. G. Carpenter, Duncan, Lawrence, C. S. Palmer.

Connecticut.—Barney, DuBois.

Delaware.—Brown, F. H. Robinson, Wood.

District of Columbia.—Mead.

Florida.—Cox, Mather.

Georgia.—Ford.

Illinois.—Arnold, Baker, Bates, Breckenridge, Brill, M. Brooks, Goodenough, Hasbrouck, Horton, Kerr, Ketchum, Kinsley, Macomber, Ricker, Short, Slocum, C. B. Stewart, A. N. Talbot, Wallace, White, Willett.

Indiana.—Esterline, Fermier, Goldsborough, Goss, Gray, Hancock, Hatt, M. A. Howe, Kenyon, Ludy, McColl, Matthews, Mees, Pence, W. P. Turner, Waldo.

Iowa.—S. W. Beyer, Bissell, Lanphear, Magowan, Marston, Meeker, Spinney, Weld, S. N. Williams, Young.

Kansas.—Diemer, Marvin.

Kentucky.—F. P. Anderson, J. P. Brooks, Faig.

Louisiana.—D. S. Anderson, Ayers, Creighton, Herget, Ordway.

Maine.—Boardman, Grover, Webb.

Maryland.—Flint, Halsted, A. W. Harris.

Massachusetts.—Adams, C. F. Allen, C. M. Allen, Anthony, Bray, Chandler, Chase, Dean, Engler, A. W. French, Hofman, Hollis, Johnson, Kinealy, Lanza, Mendenhall, Ostrander, Park, D. Porter, Puffer, R. H. Richards, Robbins, Sedgwick, A. L. Smith, H. B. Smith, W. B. Snow, Swain, H. P. Talbot, D. L. Turner, Tyler, Whitney.

Michigan.—Bixby, Cooley, Denison, F. W. Denton, Fisher, Frink, Hood, McNair, Miggett, Morley, Reynolds, Sperr, Vedder, Ziwet.

Minnesota.—Brooke, Constant, Henry T. Eddy, Flather, Frankforter, Groat, Haynes, Hoag, F. S. Jones, Kavanaugh, Schmidt, Shepardson, Springer.

Mississippi.—Drane, Hume.

Missouri.—Fernald, Greene, E. G. Harris, Hedrick, J. M. Kent, Ladd, Langsdorf, Maitland, Moore, W. K. Palmer, Richardson, Spalding, Timmerman, Van Ornum, Waddell, C. M. Woodward.

Montana.—Gill, Thaler.

Nebraska.—Chatburn, Davis, Price, C. R. Richards, Stout.

Nevada.—Stubbs.

New Hampshire.—Fletcher, Hawes, Hazen, Holden, Mann, Nesbit, Pettee.

New Jersey.—J. E. Denton, Ganz, A. C. Humphreys, Jacobus, H. S. S. Smith, Titsworth.

New York.—Aldrich, Barr, Berg, J. S. Brown, Browne, Burr, R. C. Carpenter, Colburn, Colby, Corthell, Crandall, Durand, Edmands, Farwell, Foyé, Griffin, Harrington, Haviland, Hibbard, Hutton, Jacoby, Jameson, F. R. Jones, Kaup, W. Kent, Landreth, McCaustland, Moran, Munroe, Norris, Pupin, Raymond, Russell, Ryan, Sever, Sheldon, H. E. Smith, C. H. Snow, Towle, Turrill, J. E. Wadsworth, Whipple, F. B. Williams, Williston, Wilson, R. S. Woodward.

Ohio.—Benjamin, Bradford, H. W. Brown, Caldwell, Horace T. Eddy, T. E. French, Heller, Hitchcock, C. S. Howe, Lane, Magruder, Neff, Orton, S. W. Robinson, Sanborn, Schneider, Stanwood, Vosskuehler.

Pennsylvania.—Ayer, T. R. Beyer, Brady, Bruegel, Carhart, Drown, Dudley, Esty, Foss, Franklin, Hamerschlag, Ives, J. P. Jackson, Kingsbury, Lambert, LaRue, Marburg, Merriman, J. M. Porter, Powell, Reber, Rondinella, Rowland, Spangler, Thornburg, M. E. Wadsworth, Walker.

Rhode Island.—Blanchard, Hill, Kenerson, Phetteplace, Randall.

South Carolina.—Kyser, Riggs, Thomas.

South Dakota.—Mathews, Solberg.

Tennessee.—Carson, Lund, Schuerman.

Texas.—Giesecke, Love, Nagle, Puryear, Scott, T. U. Taylor.

Utah.—Jenson.

Vermont.—Barrows, Freedman, E. Robinson, Votey.

Virginia.—D. C. Humphreys, Jett, Randolph.

Washington.—Fowler, Fuller, More, Roberts.

West Virginia.—Emory, C. R. Jones.

Wisconsin.—Bull, Burgess, D. C. Jackson, Mack, Maurer, Phillips, Richter, L. S. Smith, W. D. Taylor, Turneaure, Zimmerman.

Australia.—Barraclough.

Canada.—Bovey, Brydone-Jack, Galbraith, Owens, Rosebrugh, L. B. Stewart, Wright.

England.—Swift.

DIFFERENT INSTITUTIONS REPRESENTED:—

Colleges and Universities teaching engineering	81
Manual Training Schools	11
Correspondence Schools (3 representatives)	1

Three institutions are represented by 13 members; one by 12; one by 11; two by 10; one by 8; four by 6; five by 5; five by 4; eleven by 3; eighteen by 2; thirty by 1. Manual Training Schools by 18.

Teachers, and, in many cases, also practicians	279
Practicians not teachers	47
Total	326

GEOGRAPHICAL SUMMARY OF MEMBERS.

Alabama	4	Maryland	3	South Dakota	2
Arkansas	1	Massachusetts	31	Tennessee	3
California	6	Michigan	14	Texas	6
Colorado	5	Minnesota	13	Utah	1
Connecticut	2	Mississippi	2	Vermont	4
Delaware	3	Missouri	16	Virginia	4
District of Columbia	1	Montana	2	Washington	1
Florida	2	Nebraska	5	West Virginia	2
Georgia	1	Nevada	1	Wisconsin	11
Illinois	21	New Hampshire	7	Australia	1
Indiana	15	New Jersey	6	Canada	7
Iowa	10	New York	46	England	1
Kansas	2	Ohio	18		
Kentucky	3	Pennsylvania	27	Total	326
Louisiana	5	Rhode Island	5		
Maine	3	South Carolina	3		

40 States, District of Columbia, Canada, and 2 foreign countries.

DECEASED MEMBERS.

Name.	Year of Election.	Date of Death.	Memoir. Vol.	Page.
Volney G. Barbour	1894	June 4, 1901.	IX,	340
Charles B. Brush	1893	June 3, 1897.	VII,	181
Eckley B. Coxe	1894	May 13, 1895.	VII,	182
Francis R. Fava, Jr.	1894	March 28, 1896.	VII,	183
Estevan A. Fuertes	1894	January 16, 1903.	XI,	372
Henry Fulton	1894	December 6, 1901.	X,	258
Herbert G. Geer	1894	March 7, 1900.	VIII,	371
John B. Johnson	1893	June 23, 1902.	X,	259
Rodney G. Kimball	1894	April 25, 1900.	X,	261
Justus M. Silliman	1894	April 15, 1896.	VII,	184
James H. Stanwood	1894	May 24, 1896.	VII,	185
Robert H. Thurston	1893	Oct. 25, 1903.	XII,	...
Alphonse N. Van Daell	1897	March 28, 1899.	VII,	186
John R. Wagner	1894	January 21, 1899.	VII,	187
Francis A. Walker	1896	January 5, 1897.	VII,	188
Nelson O. Whitney	1893	March 17, 1901.	IX,	339
De Volson Wood	1893	June 27, 1897.	V,	325

PAST OFFICERS.

Special Committee for Division E (Engineering Education), World's Engineering Congress, 1893.

IRA O. BAKER, Chairman, HENRY T. EDDY, Vice-Chairman,
WM. R. HOAG, Secretary, C. FRANK ALLEN, Secretary, *pro tem.*,
MORTIMER E. COOLEY, SAMUEL W. STRATTON,
STORM BULL.

PRESIDENTS

DE VOLSON WOOD,* 1893–4,
GEORGE F. SWAIN, 1894–5,
MANSFIELD MERRIMAN, 1895–6,
HENRY T. EDDY, 1896–7,
JOHN B. JOHNSON,† 1897–8.
THOS. C. MENDENHALL, 1898–9,
IRA O. BAKER, 1899–1900,
FRANK O. MARVIN, 1900–01,
ROBERT FLETCHER, 1901–02,
CALVIN M. WOODWARD, 1902–03.

VICE-PRESIDENTS

SAMUEL B. CHRISTY, GEORGE F. SWAIN, 1893–4,
ROBERT H. THURSTON,‡ FRANK O. MARVIN, 1894–5,
FRANK O. MARVIN, CADY STALEY, 1895–6,
JOHN GALBRAITH, JOHN M. ORDWAY, 1896–7,
THOMAS C. MENDENHALL, HARRY W. TYLER, 1897–8,
C. FRANK ALLEN, HENRY W. SPANGLER, 1898–9,
ROBERT FLETCHER, CHARLES D. MARX, 1899–1900,
THOMAS GRAY, ALBERT KINGSBURY, 1900–01,
STORM BULL, CALVIN M. WOODWARD, 1901–02.
JOHN J. FLATHER, FRED W. McNAIR, 1902–03.

TREASURERS.

STORM BULL, 1893–5,
JOHN J. FLATHER, 1895–9,
CLARENCE A. WALDO, 1899–02,
ARTHUR N. TALBOT, 1902–03.

SECRETARIES.

JOHN B. JOHNSON, 1893–5,
C. FRANK ALLEN, 1895–7,
ALBERT KINGSBURY, 1897–9,
EDGAR MARBURG, 1899–1900,
HENRY S. JACOBY, 1900–02.
CLARENCE A. WALDO, 1902–03.

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* Died June 27, 1897. † Died June 23, 1902. ‡ Died Oct. 25, 1903.

Members of Previous Councils.

Terms of Office Expired in 1894.

M. E. Cooley,	H. T. Eddy,	W. F. M. Goss,
W. R. Hoag,	S. W. Robinson,	H. W. Spangler,
	R. H. Thurston.‡	

Terms of Office Expired in 1895.

H. T. Bovey,	W. H. Burr,	O. H. Landreth,
Mansfield Merriman,	W. G. Raymond,	G. F. Swain,
	De Volson Wood.*	

Terms of Office Expired in 1896.

I. O. Baker,	Storm Bull,	S. B. Christy,
John Galbraith,	J. B. Johnson,†	F. O. Marvin,
	C. D. Marx.	

Terms of Office Expired in 1897.

H. T. Eddy,	J. J. Flather,	J. P. Jackson,
Albert Kingsbury,	L. S. Randolph,	S. W. Robinson,
	R. H. Thurston.‡	

Terms of Office Expired in 1898.

C. F. Allen,	C. L. Mees,	Mansfield Merriman,
J. M. Ordway,	W. G. Raymond,	Cadey Staley,
	R. S. Woodward.	

Terms of Office Expired in 1899.

Arthur Beardsley,	Robert Fletcher,	John Galbraith,
William Kent,	T. C. Mendenhall,	W. H. Schuerman,
	M. E. Wadsworth.	

Terms of Office Expired in 1900.

Storm Bull,	L. G. Carpenter,	Albert Kingsbury,
F. O. Marvin,	R. B. Owens,	R. L. Sackett,
	R. H. Thurston.‡	

Terms of Office Expired in 1901.

T. M. Drown,	M. A. Howe,	I. N. Hollis,
Gaetano Lanza,	P. C. Ricketts,	R. G. Thomas,
	C. M. Woodward.	

Terms of Office Expired in 1902.

Brown Ayers,	G. W. Bissell,	J. J. Flather,
W. T. Magruder,	F. W. McNair,	J. M. Porter,
	A. J. Wood.	

Terms of Office Expired in 1903.

C. Frank Allen,	D. C. Jackson,	N. C. Ricker,
J. P. Brooks,	Edgar Marburg,	A. L. Williston,
	J. C. Nagle.	

* Died June 27, 1897. † Died June 23, 1902. ‡ Died Oct. 25, 1903.

CONSTITUTION

OF THE

Society for the Promotion of Engineering Education.

1. NAME.—This organization shall be called the SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.

2. MEMBERS.—Members of the Society shall be those who occupy, or have occupied, responsible positions in the work of engineering instruction, together with such other persons as may be recommended by the Council.

Honorary Members of the Society shall be such persons as may be recommended by unanimous vote of the Council after a letter ballot. They shall not have the right to vote, shall not be eligible to office, and shall not be required to pay any fees or dues.

The name of each candidate for membership shall be proposed in writing to the Council by two members to whom he is personally known. Such name, if approved by the Council, shall be voted on by the Society at the annual meeting.

3. OFFICERS.—There shall be a President, two Vice-Presidents, a Secretary and a Treasurer, each to hold office for one year. They shall be chosen by vote of the members at the annual meeting.

4. COUNCIL.—The Council of this Society shall consist of twenty-one elective members, one-third of whom shall retire annually. The officers and the past Presidents of the Society shall be members of the Council *ex officiis.*

Any member of this Society shall be eligible to election to the Council, provided that not more than one elective member shall be from any one college.

Members of the Council shall be elected by ballot by the Society, at its annual meeting.

The Council shall constitute a general executive body of the Society, pass on proposals for membership, attend to all business of the Society, receive and report on propositions for amendments to the constitution, and shall have power to fill temporary vacancies in the offices.

5. NOMINATING COMMITTEE.—The Nominating Committee shall consist of the Past Presidents and the seven elective members of the Council retiring the following year, provided, however, that if, of this committee, the number in attendance at any

meeting be less than five, the President shall make appointments so as to form a committee of five.

6. Fees and Dues.—The admission fee, which shall also include the first year's dues, shall be three dollars, and the annual dues thereafter three dollars, payable at the time of the annual meeting. Those in arrears more than one year shall not be entitled to vote, nor to receive copies of the Proceedings, and such members shall be notified thereof by the Secretary one month previous to the annual meeting. Any member who shall be in arrears more than two years and shall have been duly notified by the Secretary, shall be thereby dropped from the roll, excepting such arrearage shall be paid previous to the next ensuing annual meeting; and no such member shall be restored until he has paid his arrears.

7. Meetings.—There shall be a regular meeting occurring at the time and place of the meeting of the American Association for the Advancement of Science, or of some one of the National Engineering Societies, or otherwise as the Council may determine.

8. Publication.—The Proceedings of the Society, and such papers or abstracts as may be approved by the Council, shall be published as soon as possible after each annual meeting.

9. Amendments.—This Constitution may be amended by a two-thirds vote at any regular meeting, the amendment having been approved by a two-thirds vote of the Council, taken by letter ballot.

RULES GOVERNING THE COUNCIL.

First. The officers of the Society shall constitute a committee to arrange the time and place of the annual meeting, and also to prepare a programme for the same.

Second. The President, Secretary and Treasurer shall constitute an Executive Committee, which shall have charge of all matters relating to the business affairs of the Society not otherwise provided for.

Third. The reading of papers shall be limited to fifteen minutes each, and abstracts of the same of about three hundred words or less shall be printed when practicable and distributed in advance to the members.

Fourth. The time occupied by each person in the discussion of any paper shall not exceed five minutes.

PROCEEDINGS OF THE NIAGARA FALLS MEETING, JULY 1–3, 1903.

In accordance with plans and discussions extending over several months, the Society for the Promotion of Engineering Education held its 1903 meeting in conjunction with that of the American Institute of Electrical Engineers. The local arrangements of the Institute, including registration, hotel accommodations, admission to power and industrial plants, excursions and other privileges were freely and courteously extended to the Society. The members of the two organizations mingled socially but held their formal meetings apart except on Friday, July 3, when a joint meeting was held of great value to this Society, a full report of which appears in this volume.

The Society's first session was called to order on July 1, at 10:30 A. M., in the Cataract House with the President C. M. Woodward in the chair. The Treasurer read his report which appears at the end of the Proceedings. An auditing committee was appointed consisting of Henry S. Jacoby and Wm. G. Raymond.

The President's address was then read. The Committee on Entrance Requirements stated that it is in active relations with various educational and learned societies and hopes to be ready to make, a year hence, a report which may be considered final. The Chairman of the Committee, H. W. Tyler, presented his resignation. Following this statement and action of the Chair-

man the Society by vote postponed the report of the Committee for one year, accepted the resignation of the Chairman and requested the President to fill the vacancy.

Professor W. T. Magruder then outlined briefly the work of the Committee on Statistics next to be undertaken.

President Woodward presented the report of the Committee on Industrial Education. The sentiment of his Committee favored the presentation of the subject of industrial education to teachers and principals of secondary schools. Accordingly three members of the Society were selected to present papers before different branches of the National Educational Association.

These papers appear in the present volume as the work of the Committee for the year just closing.

In the absence of the Chairman, Chas. F. Burgess, of the Committee on Technical Books for Libraries, the report was read by Professor C. Frank Allen of the Committee. This report aroused considerable discussion as the result of which a committee consisting of A. L. Williston, Wm. G. Raymond and C. A. Waldo was appointed to consider the report and recommend to the Society some action concerning it. Subsequently Professor Williston offered the following with the unanimous approval of his colleagues, the same receiving the unanimous affirmative vote of the Society.

"Your Committee appointed to consider the report of the Committee on Library Books begs leave to recommend that the report of the Library Committee be accepted for publication in Volume XI. of the Society's Proceedings with the thanks of the Society for

the painstaking and careful work which that committee has done upon it; and further we recommend that the Secretary be instructed to have printed in the usual pamphlet form as many extra copies as in his judgment may be necessary for distribution to those who may inquire for it.

"If in the final editing of the report for this purpose the Library Committee desires to avail itself of the services of this Society for the purpose of circulating a limited number of copies of the report, to such persons as it may desire, for suggestion, we recommend that the Secretary be instructed to furnish every possible assistance.

"We also recommend that the Library Committee be continued."

On Wednesday evening, July 1, the Society met in the usual place in the Cataract House. The paper by Arthur W. Ayer on "Engineering Education from the Point of View of the Practicing Engineer" was read and was followed by that of John Price Jackson on "Methods of Study for Technical Students." Both were freely discussed.

Wm. G. Raymond presented a verbal report from the Committee on Requirements for Graduation. He asked and was granted another year before filing a formal report.

The first session on Thursday, July 2, was called to order by President Woodward at 10 A.M. The Secretary's annual report was read and accepted and will be found at the end of the Proceedings.

The applications and credentials of the following

candidates having been examined and approved by the Council they were duly elected to membership in the Society: Charles Metcalf Allen, Onward Bates, Harold Sherburne Boardman, Joseph Stanford Brown, Nelson Holt Cox, Walter Hugh Drane, Horace Taylor Eddy, Samuel Sumner Edmonds, J. Walter Esterline, Emile Jerome Fermier, Arthur Hillyer Ford, Charles Evan Fowler, Andrew Ernest Foyé, Albert Frederick Ganz, William Nathan Gladson, Arthur Maurice Green, Jr., Arthur Orton Hamerschlag, Edward Lee Hancock, John Lyle Harrington, Charles Alfred Hasbrouck, Ira Grant Hedrick, Albert Henry Heller, Albert Marion Herget, George Ferry Horton, Alexander Crombie Humphreys, Joseph Moore Jameson, Joseph Jenson, Frederick Scheetz Jones, William J. Kaup, William Herbert Kenerson, James Martin Kent, Alfred Monroe Kenyon, Milo Smith Ketchum, Carl Kinsley, Alexander S. Langsdorf, Llewellyn V. Ludy, Alexander Maitland, Jr., Warren H. Meeker, Daniel Edward Moran, Charles Skeele Palmer, Charles Francis Park, Thurston Mason Phetteplace, Emery Halbert Powell, William Lewis Puffer, Otis Everett Randall, Herman White Reynolds, James Perkins Richardson, William Jackson Roberts, Lino Francesco Rondinella, George Herbert Rowe, Arthur John Rowland, Walter Basford Russell, Herman Schneider, Arthur Curtis Scott, George Francis Sever, Samuel Sheldon, Roy Harley Slocum, Leonard S. Smith, Alfred Alexander Titsworth, Sharman March Turrill, John Findlay Wallace, Laenas G. Weld, Lewis Emanuel Young.

The President appointed the following Committee on nominations for officers for the ensuing year: Messrs.

Baker, Raymond, Gray, Jacoby, and Fuller. The Auditing Committee made its report, which was adopted and is appended to the Treasurer's report.

In the Council meeting just preceding the business meeting here reported, it was shown that amendments to the Constitution of the Society are desirable and that it might be well to rewrite it completely. Upon motion a Committee, consisting of the Secretary, President and Treasurer, acting as Executive Committee was instructed to formulate desirable amendments to the Constitution and secure letter ballots upon them by the Council, that they may come before the next annual meeting of the Society for final action.

The following papers were read and discussed at the morning session: "Two Kinds of Specialization and Fundamental Principles in Place and out of Place," by Arthur N. Williston; "The Rating of Laboratory and Class-room Work in Schedules of Courses," by Francis C. Caldwell; "Practical Astronomy for Engineers," by Charles S. Howe; "Education Preparatory to Factory Management," by Hugo Diemer.

At the evening session on Thursday, July 2, the Nominating Committee reported recommendations for officers for the ensuing year. The report of the Committee was adopted and for the several offices of the Society members were chosen whose names appear on the early pages of this volume.

Preliminary to the papers of the evening Professor J. L. Van Ornum, of Washington University, gave an account of some interesting experiments upon the behavior of certain materials under stress. Walter M. Riggs with the aid of lantern slides presented his

paper upon the "Equipment of an Electrical Engineering Laboratory." Following this the Secretary read the papers of A. H. Blanchard upon "Engineering Jurisprudence an Essential in the Engineering Curriculum," and of J. A. L. Waddell upon "The Advisability of Instructing Engineers on the History of their Profession." The latter paper advocated the organization within the Society of an editorial staff which should undertake the compilation of such a history of the engineering profession as in the author's opinion is now greatly needed, and was discussed in writing by many members. At the conclusion of the debate a Committee consisting of A. L. Williston, Wm. G. Raymond, and Mansfield Merriman was appointed to take the proposition into further consideration and report at the next annual meeting.

The Society then adjourned to conclude its annual meeting on the next day, Friday, July 3, by holding a joint session with the American Institute of Electrical Engineers in the auditorium of the Natural Food Company.

Arrangements for the Joint Meeting with the American Institute of Electrical Engineers had given precedence on the program and assigned nearly all of the papers to members of the Institute, which was represented by the following papers:

Professor W. S. Franklin on "The Teaching of Physics to Engineering Students"; J. G. White on "The Problems that are Facing the Electrical Engineer of To-day and the Qualities of Mind and Character which are Needed to Meet Them"; Bancroft Gerardi, Jr., on "The Proper Qualifications of Electrical

Engineering School Graduates from the Telephone Engineer's Standpoint"; L. A. Osborne on "The Proper Qualifications of the Electrical Engineering School Graduates from the Manufacturer's Standpoint"; E. H. Mullin on "Training an Artist in the Forces of Nature"; T. J. Johnson on "Engineering English."

The Society was represented by Professor D. C. Jackson on "The Typical College Courses Dealing with the Professional and Theoretical Phases of Electrical Engineering."

The discussion of these papers was reported by the Institute stenographer and is given in full in this volume. The entire session was a unique and valuable experience for members of the Society.

The following members were in attendance: B. J. Arnold, H. J. Ryan, A. F. Ganz, J. P. Jackson, W. E. Goldsborough, Samuel Sheldon, W. H. Browne, Jr., G. S. Macomber, F. W. Springer, W. S. Franklin, A. J. Wood, J. W. Esterline, F. L. Emory, H. T. Eddy, Jr., D. C. Jackson, A. S. Langsdorf, C. M. Woodward, W. F. Magruder, W. M. Towle, L. Duncan, C. A. Waldo, E. G. Harris, C. L. Crandall, W. H. Meeker, A. M. Kenyon, H. Diemer, W. M. Riggs, H. H. Kyser, A. N. Talbot, C. F. Allen, R. H. Slocum, E. H. Powell, H. C. Solberg, C. L. Mees, H. S. Jacoby, W. G. Raymond, F. C. Caldwell, J. L. Van Ornum, T. Gray, F. E. Turneaure, C. S. Howe, M. A. Howe, F. Galbraith, I. O. Baker, R. B. Owens, A. H. Fuller, J. E. Denton, H. P. Talbot.

Report of the Secretary.

The membership of the Society, at the opening of the last meeting, was 253. During the meeting thirty-two applicants

for membership were elected, all of whom duly qualified. During the year just closed two members were dropped for non-payment of dues and two resigned, leaving the membership at the beginning of the present meeting 271. One death among the members has been reported, that of Professor Estevan A. Fuertes, of Cornell University.

In addition to his ordinary routine work, the Secretary compiled a combined index of the Proceedings to date and carried on an extensive correspondence and made a large use of the printed matter of the Society, in an endeavor to reach the more recent additions to the teaching forces of engineering education, and to inform them concerning the work that this Society is doing. CLARENCE A. WALDO, *Secretary.*

REPORT OF TREASURER.

The Treasurer would respectfully report as follows:

The total receipts during the year 1902–03, as given in the statement herewith, were $1,245.09, of which $726.00 were for current dues.

There is at present a balance of $337.28, a gain of $20.31 over that of a year ago.

A condensed statement of receipts and expenditures for the year is here given.

RECEIPTS.

Cash from former Treasurer	$316.87
Sale of Proceedings	134.20
Sale of reprints to authors	23.02
Past dues collected	39.00
Current and future dues	732.00
	$1,245.09

EXPENDITURES.

Stenographer at Pittsburg meeting	80.00
Printing Volume X. of Proceedings	502.91
Express and other expense on same	51.51
Reprints of papers for authors	23.97
Secretary's supplies and expenses	121.13

Secretary's honorarium......................	50.00
Treasurer's supplies and expenses............	22.05
Committee on Entrance Requirements........	11.40
Committee on Statistics.......................	24.84
Indexing Proceedings.........................	20.00
Balance, cash on hand........................	337.28
	$1,245.09

Respectfully submitted,

ARTHUR N. TALBOT, *Treasurer.*

The Committee appointed to audit the report of the Treasurer respectfully report that they have examined the accounts and compared the vouchers with the items in the report and find the same to be correct. A record of this examination and approval has been entered in the Treasurer's book.

[Signed] HENRY S. JACOBY,
WM. G. RAYMOND,
Committee.

ADDRESS BY THE PRESIDENT.

PROFESSOR CALVIN M. WOODWARD,

Dean of the School of Engineering and Director of the Manual Training School, Washington, St. Louis.

The Promotion of Engineering Education Through Improvements in the Secondary School.

Engineering education is promoted by promoting the secondary school which naturally leads to engineering. It has been and still is my privilege to be closely connected with the organization and work of both secondary and engineering schools, and I am therefore quite familiar with what is doing in these fields. The situation is extremely encouraging, and I feel sure you will gladly give a quarter of an hour to its examination.

Secondary education is gradually becoming general, and its character is becoming broad and practical. Professor G. G. Ramsey, of the University of Glasgow, said last November in an address on "Efficiency in Education," while speaking of the need of new definitions and new standards in education:

"It is not merely that new subjects have been introduced for which a place must be found; but also that the demand for higher education of some sort, and of the best sort available, is being made on behalf of a much wider and larger class than formerly. It is no longer a select class, consisting of those destined for professions and the higher walks of life, whose needs demand attention; the nation has at last been roused to the necessity, which many of us have been preaching all

our lives as a matter of national concern, of training to the utmost the brain power of the community, and of bringing within the reach of every capable mind, in every class, the benefits of a liberal education."

"There is," he adds, "at this moment a boom on amongst us in this matter of higher education; and it is of the greatest consequence to the country that this boom should expend its force in the most promising directions."

In the course of his address this eminent "Professor of Humanity" frankly admits that "the highest literary and classical education appeals to only one side of human culture."

The rapid growth of the secondary school in the United States cannot escape observation. The increased range and efficiency of the grammar schools is partly the cause and partly the consequence of increased privileges in the way of high schools. The number of secondary students in public and private high schools and academies increased from 3,500 to the million people in 1891, to 5,800 to the million in 1901 —a gain not in the attendance merely, but in the ratio, of 66 per cent. This for the country at large. In some states, and more especially in the large cities, the gain has been remarkable.

This result is strikingly shown in the records of Kansas City, Mo. Its high school attendance has in six years increased one hundred per cent., while its population has increased *fifty* per cent. This is largely explained by the organization and equipment of what appears to me to be the largest and most successful manual training high school in the world. The enroll-

ment at the manual high has been as follows: beginning with its start 1897: 842, 1,114, 1,244, 1,492, 1,677, 1,706 in 1903.

I find it necessary to say a word in explanation and defence of the situation in St. Louis. In St. Louis the Board of Education is building two fine manual training high schools, which will be opened for 2,000 students next year. These schools have long been necessary, but an unfortunate provision in the State Constitution kept the school tax at so low a rate that the secondary feature was greatly neglected. Nearly a year ago the Constitution was amended, raising the limit of taxation for schools from four mills to six mills per dollar of assessed value, or a dollar and a half of actual value. To a surprising degree the prospect of the new schools has strengthened the higher grammar grades. The feeling that the high schools belong to all children is taking deep root, and I predict that the high school attendance in St. Louis will double within two years.

The gains have been about equal east and west. The high school attendance has increased 48 per cent. in Springfield, Mass., while the population has increased 19 per cent. In Worcester, Mass., the high school attendance increased 124 per cent., while the population increased 36 per cent.

Manual training was established in Philadelphia in the face of every kind of opposition. The original plan was for the establishment of four manual training high schools, to be located in the four chief centers of population. The first school was opened in 1885, with 114 pupils, in a deserted primary school building which has

since been enlarged several times; the second was opened in 1890, with 117 pupils also in an old primary school building. An appropriation has been made this year for a fine new building for the third manual training school which will be opened as soon as the building is finished. The fourth will soon follow. Meanwhile, an appropriation of $400,000 has been made for a commodious and fully equipped building for the second school, and the same provision will be made for the first school before a great while.

There has never been more than one high school of the old type in Philadelphia. This year it moved into a magnificent new building. The enrollment in the first manual training school for the year now closing was 638; and in the second 580. The third school will be much larger than either of the two preceding ones, but it will probably be filled with students as soon as it is ready; while the new building for the second school will furnish larger accommodations and thereby increase the attendance. In 1885, when the first manual training school was opened, the enrollment in the Central Classical school was 610. As a matter of fact, the attendance at that school had been almost stationary for over twenty years. The total high school enrollment is about four times as great as it was in 1885, and it would have been five times as great had there been room.

The progress of events in Indianapolis, Ind., illustrates both the growth of the secondary schools and the direction of that growth. At the close of the school year this spring 580 pupils passed into high schools—180 into the older, literary high school and 400 into the manual training high school.

The remarkable strength of the secondary schools of Boston and Chicago is due in part to the breadth of opportunity offered to their graduates in the Massachusetts Institute of Technology and Harvard University, in one city, and to Armour and Lewis Institutes and Chicago University in the other; and in part to the introduction of manual training on a high plane. In each city the demand for manual training far outruns the accommodations, and additional manual training high schools must soon be equipped. It would be unreasonable to attribute this growth to any one thing, as for instance the introduction of manual training. Beyond question that has had much to do with it, but increased wealth, improved social conditions, and a growing conviction that modern education is a good business investment, have had much to do with bringing about this gratifying result. Twenty years hence, secondary school diplomas will be relatively as numerous as elementary school diplomas were twenty years ago.

In every instance manual training high schools look straight towards engineering schools, and the growth of the former leads inevitably to growth in the latter. Up to a year ago the best feeder of the engineering school of Washington University was the St. Louis Manual Training School; now the public school is taking the lead.

When the first manual training high school was opened in Philadelphia, the cheerful prediction was made that it would "probably graduate a degraded mass of operatives." Now I am told that as large a number of graduates, if not more, go from the manual

training schools to universities as from the old Central High School.

I am under the impression that about fifty per cent. of the graduates of the Chicago Manual Training School go on into higher education, a majority into engineering schools. About 30 per cent. of the graduates of the St. Louis school go on into higher education, chiefly but not exclusively into engineering. The Law School and the Medical School get a few every year.

The work for this Society to do is to encourage the establishment and help on the through work of secondary schools of a somewhat technical character.

English engineering education is at present fatally weak from having no adequate system of secondary schools. From what is practically a grammar grade they plunge their students into what they call engineering. Often they put their boys through a literary and mathematical course and then into a machine shop for two or three years, and then call them mechanical engineers. They attempt teaching all kinds of engineering in night schools to students who work during the day. Moderate technical teaching is of course possible and proper under such conditions, but we should not call it engineering.

An English machinist who called himself a professor of engineering, once told me that we in St. Louis wasted three years in our manual training school; the boys, he said, ought to take up engineering at once.

It is difficult to feel much respect for such shallow engineering; certainly we can not claim for it the dignity and scholastic rank which we properly claim for the work of a typical American engineering school.

To be sure I found at South Kensington facilities for training engineers of a high grade—though their engineering laboratory was dreary enough, and the attendance of students was small. Professor Perry's address of a year ago is a confession of insufficient secondary training in fundamental principles before engineering proper is taken up. Note also the movements in the London Board by Lord Rosebery and announced in our papers two days ago.

Suggestions.

I wish now to make two practical suggestions: First, that in every community large enough to maintain two high schools, one of them to be organized as a manual training high school, allowing the other to maintain more or less rigidly the traditional literary curriculum, without opposition or criticism.

The second suggestion is that the theory and use of tools and fundamental processes of construction, with the rudiments of mechanical drawing, be relegated from engineering schools to the secondary schools as rapidly as possible. I will venture a few words on each of these points.

Of course I believe that manual training should enter into the education of every boy during the secondary. period. The secondary school should enable a boy *to discover the world,* and *to find himself.* A boy finds himself when he has taken a correct inventory of his inherited and acquired tastes and capacities. If the secondary school shall do these two things, it will do what generally has never been done at all. But this cannot be done with a single curriculum, along any line.

When the whole boy has been put to school three or four years he finds out what his strong points are, if he has any, and he can find out in no other way, and having found his inborn aptitude and peculiar stronghold he works into the occupation where he is most likely to achieve success; it may be engineering, it may be architecture, and it may be neither, the result is equally beneficial. This is a superb function of the secondary school, and every pupil should stay in school till he has secured the benefit of it. Nothing in education can outweigh the importance of the two discoveries: the external world, and one's self. The elementary school comes too early, and the college and real life come too late. The secondary school is a place for discovery and intelligent choice.

Nevertheless we must not ignore the fact that the force of educational traditions is very great. The great body of school principles and superintendents had no manual training, as we understand the term, in their development, and to a very great extent they still misunderstand and underrate it. The great mass of American teachers has as yet no adequate conception of the fine invigorating effect of a correct system of manual training upon the mind of a healthy, normal boy. Hence, when it is injected into an old high school, it is given the cold shoulder, the icy stare, and the back seat. Doubtless you have seen this, for in some form, every city in the land has done something in manual training; but my observation is that it flourishes best when the whole school participates in it, and when every teacher in the school believes in it.

The second suggestion, that manual training and

drawing be regarded as legitimate work for the secondary school, needs little to support it. In the first place the boys need it in their mental, moral and physical development. From its active character it appeals strongly to boys in their early teens, and for the most part the principles are comprehensible to boys. Finally it will leave the engineering school free to put its students into the engineering laboratory instead of into the shop, and into detail drawing preparatory to design, instead of taking the rudiments. All this will involve a great gain to the engineering school as well as to the preparatory school.

The time is near at hand when we can demand a thorough course of manual training in our entrance requirements. It is already admitted among the elective subjects by some of our schools. Our committee on entrance requirements will soon present some definitions which I trust will meet your approval.

I hope whenever manual training is presented by an applicant for admission to a school of engineering, the candidate will be given a practical test. In St. Louis we always apply it when a student claims that he is proficient, and the effect is fine. One's ability to read or make a drawing and to execute a piece of tool work from a drawing can be shown about as readily as a knowledge of geometry or physics. It is safe to place no value on specimen exercises in shop work and drawing brought along from a preparatory school. On the other hand, work well done before your eyes is unmistakable and well equipped students take pleasure in presenting it. The incompetent boy will rarely ask for a practical test.

In Washington University the freshmen and sophomores are classified into: boys who have had shop, and drawing, and boys who have not had those branches. With manual training in all secondary schools such a division will be unnecessary.

Warnings.

Years ago I found it necessary to warn people of certain fallacies and misconceptions. There is less need of warnings to-day, yet there are dangers. Some people still think that manual labor is manual training, just as they probably think that the boy who fetches and carries books in a library is becoming a literary man. Others think a manual training school should be a factory, and should put its goods on the market. Still others think that the chief product of manual training is found in bits of furniture and knick-nacks which pupils carry home. It is constantly necessary for us to explain that ordinary manual labor is not manual training at all. There is training in mastering the theory and the use of a tool or a machine under the guidance of an expert; but when the mastery is gained, and gained thoroughly, there is no training in its continued use, which is not for education but is for cemmercial ends.

My usual reply to people who betray such misconceptions is already gray with age, but it may be allowed a positively last appearance here—the more a school becomes a factory the less is it a school. The school should put one article upon the market and that is, boys; and if all the shop exercises of the year were at its close put into a furnace and burned, all the manual training would remain.

Again, it is constantly necessary to remind people that drawing is an essential part of manual training, and yet in a well regulated school the manual features occupy the attention and absorb the energy of the average boy only one third of the hours he gives to school and its duties.

Dangers.

There are however serious dangers threatening the manual training movement. I will mention some. Its premature introduction into the lower grades; a mistake as to its object; faulty methods of teaching, or the neglect of all teaching.

It is a fatal mistake to attempt to teach the theory of tools and logical processes of construction to boys below their teens. Little fellows may play with tools, and they can learn something, but the rigor and logic of correct methods and exact workmanship on abstract principles are beyond them; the work degenerates, and their interest wanes. In either case the attempt fails; and the boy is more or less spoiled, and comes later to the work with feeble interest and strong prejudices.

The greatest danger however arises from faulty methods of teaching, or rather no teaching at all. I cannot too strongly condemn the wishy-washy tinkering with tools and materials, where the child is the victim of his own whims and of his teacher's ignorance; where under the pretence of developing originality, initiative, altruism, or concrete expression, the child is prematurely misled, misdirected, neglected and mistreated, until the possibility of well-timed and well-regulated manual training is utterly lost. I regret that I must speak so strongly of a tendency to utterly emasculate

manual training by a method of treatment which would be instantly condemned if applied to any other branch of study. I have known young fellows practically turned loose in a shop supplied with tools and lumber, and told to make what they liked, with no instruction as to methods of exact workmanship, and no knowledge of how parts are joined together; the consequence was a waste of time and material, a dulling of edge tools, and a more serious dulling of the edge of interest. The results are shameful constructions and general disgust. We must stand on our guard against these mistakes.

The Dignity and Worth of Engineering.

Finally we must stand up for the dignity and intrinsic worth of knowledge and skill which is directly useful. There is a disposition among school men to underestimate the disciplinary and culture value of applied science because it is useful. They question the motives of one who asks a training which is going to be directly valuable to him in making a living, and in the way of business. They fear his motives must be sordid and low. On the other hand they seem forced to conclude that when one asks for something which is likely to be of no use in practical affairs, his motives must be pure and high.

Let us stoutly maintain that no students are more high-minded, no more unselfish, no more patriotic, no more altruistic, than ours. That the measure of one's worth in the world is in his usefulness to himself, his family, his community.

The new education is a high and noble education and we need not hesitate to champion it in all places and all

times, with confidence and pride, as Professor Swain recently did in the columns of the New York *Tribune,* and as Professor Thurston and others will do next week in Boston?

As Professor Pritchett has well said, the gift of science is the priceless gift of a new scholarship. It has given new subjects to the curriculum, and it has given new dignity to the practical arts, and the spirit of the age demands that that priceless scholarship shall be applied to the needs and problems of our daily life.

The world is full of unsolved problems, and the engineers, the men skilled in the application of science, are to solve them. The earth is ours and the fullness thereof. The arid lands are to be made moist and fertile. The swamp lands are to be made dry and fertile. The wealth of mines and forests is ours. Our mighty engines are the hewers of wood and the drawers of water. We sow and harvest and grind and mix and bake by machinery. We light and heat and travel by machinery; and ours is the noble mission to train the architects and engineers of all these glorious functions. Let us rejoice and magnify our work. Let all the world know that there is nothing nobler or finer than the accomplished, cultivated engineer. Let the rising generation understand that in our engineering schools and in the secondary schools which lead up to them, we are combining manual with mental training; we are putting the mechanic arts, and the liberal arts side by side into the same curricula; we are dealing simultaneously with material forces and appliances, and with spiritual forces and appliances; we are cultivating not alone or chiefly, the memory and under-

standing of books, but the judgment and the executive faculties as well; that we are extending the humanities so as to include human life, human activities, and human needs as they exist now and here.

REPORT OF THE COMMITTEE ON INDUSTRIAL EDUCATION.

During the last year the Council seriously considered the plan of holding the annual meeting of 1903 in connection with the National Educational Association in Boston. Difficulties of various kinds arose until it became evident that such a meeting was inexpedient for the Society for the Promotion of Engineering Education. In lieu of a meeting in conjunction with the N. E. A. it was arranged that three members of the Society should present every one a paper before as many different sections of the National Association upon some features of industrial and technical education. Places for these three papers were found upon the program of the National Association and the men to write them were selected from the Committee on Industrial Education.

It was then agreed that these several papers, prepared by members of the Committee on Industrial Education, should be printed in the current volume of the Proceedings as the report of that committee for the year 1903.

The papers in question were written by the President, C. M. Woodward, by Director R. H. Thurston of Cornell, and by Director Arthur L. Williston of Pratt Institute. These papers follow in their order.—[Eds.]

THE NEW OPPORTUNITY FOR THE SECONDARY SCHOOL.

BY C. M. WOODWARD,

Dean of the School of Engineering and Architecture, Washington University, St. Louis.

The curriculum of the secondary school must be broadened. The demand for it comes from new constituencies with increasing emphasis every year. Secondary education is rapidly becoming universal, and its form and content must take into account new fields of activity for educated people. The curriculum must adapt itself to modern requirements. It must touch modern life, modern conditions, modern forces, modern responsibilities. As Huxley expressed it: "It is folly to continue, in this age full of modern artillery, to train our boys to do battle in it equipped only with the sword and shield of the ancient gladiator." Sir Lyon Playfair changed the figure in protesting against the English system of secondary education, as follows: "In a scientific age and in an industrial section, an exclusive education in the dead languages is a curious anomaly. The flowers of literature should indeed be cultivated, but it is not wise to send men into our fields of industry to reap the harvest, when they have been taught to pick the poppies and push aside the wheat."

When the wide-awake inquisitive boy knows that electricity, and steam, and heat, and the art of designing and constructing automatic machines, can be studied and understood with no more effort and in less time

than it takes to commit to memory a Latin grammar, or to read Demosthenes without a dictionary; and that those former things are ten times as interesting as the latter, and a hundred times as likely to be of service to him in the struggle for life and the battle for success—he will choose them if he has a chance. And it is our business to give him a chance.

We want living languages and living issues. We must teach the duties of the American citizen rather than the manner of life of a slave-owner in Athens or Babylon; not merely what may be the solace and delight of a man of leisure, but what will increase his value and use in practical affairs. We must teach the mechanics, hydraulics, electricity, and chemistry of to-day rather than the doctrines of Aristotle and the alchemists. We must illustrate and explain the battle of Santiago rather than the battle of Salamis. It is a thousand times more interesting and more useful to the average boy to know how modern engineers tunneled under the Alps, than to read the fabulous stories of how Hannibal made a road over them; to know how Eads built a railway bridge across the Mississippi, than to decipher Cæsar's foot-bridge over the Rhine; to analyze and comprehend the water works of Boston, St. Louis, or London, than the hydraulic system of ancient Rome, marvelous as it was; to master the universal language of drawing, than to get a smattering of a language which no one speaks and no one writes; to become familiar with modern methods of construction and the skillful use of tools and machinery, than to speculate over the Tower of Babel or the Pyramids of Egypt. As Emerson said, we must take the step

from knowing to doing, and we must teach the rising generation to do the things that the world to-day wants done.

Here is the magnificent opportunity for the secondary school; to use a military phrase, let it change front and face the world of to-day. Let it open all its doors and windows to the humanities of to-day. Look around and look forward, not always backward. Weep not, as Ruskin did for departed days, for the lumbering stage-coach, the storm-driven wooden ships, the hand loom, the log hut, and the good old days of blissful feudalism. I am amazed when I think how much we are spell-bound by tradition. Perhaps I have been as foot-loose as any of you, yet I find myself continually approving of educational features for no good reason except that they are fashionable. We somehow seem to think it means far more and is in far better form to know that certain nymphs gave Perseus a helmet which Vulcan made for Pluto, and which rendered him invisible, than to know that Thomas A. Edison invented the incandescent lamp and made it possible for Niagara Falls to light a whole city twenty-five miles away; and yet we don't believe one word of the former story, while we accept every word of the latter.

It is of course a matter of association. Sir Lecester Deadlock, in "Bleak House," could not endure a man who experimented with a steam-engine and who seemed quite at home with a coal-burning furnace. He drew inferences as you and I do. Sir Lecester inferred that the man who understood engines and power houses must be ignorant of polite learning and unfamiliar with the ways of good society. So you jump to the conclu-

sion that the man who knows all about Edison and the generation of electricity by a waterfall is probably ignorant of Greek mythology and not very proficient in spelling.

Well, perhaps you are right and perhaps you are wrong. But this is certain: It is no longer safe to assume that your engineer or your electrician is an uneducated man, or that he lacks culture. There is more than one kind of culture. Emerson speaks of "having a mechanical craft for culture." By culture I mean a knowledge of some of the best things that have been said and done in the world; a certain refined and gracious spirit; a soul of honor; a depth of human sympathy; a wise and understanding heart; an all-pervading love for what is useful and true, and therefore good and beautiful. That kind of culture can be gained with or without much ancient literature; with or without much mathematics; with or without the physical, biological, or dynamic laboratory; with or without the art-room or the drafting-room; with or without the theory of typical tools and correct methods of construction. But there is no necessary divorce between the skilled hand and the cultured mind; both are needed for the highest culture.

President Wilson says that the colleges are not planned for the majority; they are for the minority. When we consider colleges of the Princeton type, we must admit that he is right. They are not for the majority. So of the classical secondary school; it is not for the majority, and the majority know it and feel it.

I am not pleading to-night for the minority who are

already in our secondary and higher schools. I am pleading for that vast majority who are not in them; who need and desire education, and who are coming with increasing numbers. The program which the majority want is fairly well known. It is in force in many cities; it is embodied in the manual training high school, and it has been met with a hearty response. I need not quote St. Louis to prove this. The Manual Training High School of Kansas City has doubled the high school attendance in six years. Similar results have been reached in other cities. The technical college or college of engineering logically follows the new kind of high school. It takes equal rank with the traditional college, and it will soon outstrip it in attendance.

When Hawthorne got through college he wrote to his mother: "I cannot become a physician and live by men's diseases; I cannot be a lawyer and live by their quarrels; I cannot be a clergyman and live by their sins. I suppose there is nothing for me to do but write books."

Now the majority who are coming will inherit no wealth; they expect and desire to earn their own living. We do not need them as lawyers, or ministers, or doctors; we hope they won't all write books; we do need them as teachers, as engineers, as accomplished workmen in our industries and in our unhistorical methods of trade and commerce. Let us persuade them that education and skill dignify and adorn every occupation; that the legitimate fruit of a combination of literary and scientific culture and technical skill in dealing with materials and forces will be a generation of

stronger, abler, and more successful men in industrial, commercial and political life.

Let us begin, if you please, by training a part of this majority in the principles underlying the crafts, rather than in such a way as to lead them to feel that they are superior to all crafts, and hence be unwilling to be put to any.

Let us avoid the serious mistake of educating the majority as though they were a privileged minority. Let us accept once and for all the doctrine that any occupation may be ennobled, enriched and dignified by education, training, and skill; that there is a score of new professions requiring a high order of intellect, and the close and continued study of subjects as difficult and as profound as are the branches which lead up to the so-called learned professions.

The educated and highly accomplished architect or engineer is a learned man, and he stands second to none in the forum and in the arena of activity to-day. There is a great and an increasing demand for such men in every city in the land. I have been training engineers for nearly half a century, and I know how inadequate the supply is. The other day I was told that there were twelve hundred educated engineers in Pittsburg, and the demand was continually for more. The number of students in the technical colleges—that is, the colleges for applied science in the various branches of engineering and architecture—ought to be as numerous as in colleges for letters and pure science, and they will be as numerous when the secondary schools recognize the majority as they now do the minority.

What has been done in Philadelphia, Kansas City,

and in some other cities, and what is now doing in St. Louis, ought to be done in every city that can maintain a high school, viz: offer facilities for a secondary education looking towards industrial occupations and technical professions equal, at least, to those offered for students looking forward to clerical or mercantile occupations and the traditional professions.

Are you doubtful about the intellectual, moral and social standing of the graduates of schools which incorporate a thorough course of manual training, including practical drafting with a modest academic course? If so, it will be of value if I give you the record of the graduates of a manual training school which has been in existence twenty-three years and has graduated 960 men in twenty classes. I refer to the school connected with Washington University in St. Louis.

Before I read the list please bear in mind that the school does not aim to produce mechanics. Not every boy is fit to be, or has the ability to be, a good mechanic. Moreover, many graduates who started life as mechanics have pushed along, and have been called up higher, to greater responsibilities and to larger rewards. At the start in the school we do not pretend to know what a boy is by nature best fitted for, nor what opportunities his environment will offer. We attach no value to the whims and fancies of a fourteen-year-old boy, and very little to the ambitious hopes of parents. When a boy stands four-square on a broad foundation training at the age of seventeen or eighteen he is pretty sure to build aright.

OCCUPATIONS OF THE GRADUATES OF THE MANUAL TRAINING SCHOOL OF WASHINGTON UNIVERSITY, ST. LOUIS, 960 IN NUMBER.

Forty-five have died, so that counting the class of last month whose occupations are "unknown," there are 915 on the list, all young, many only boys still:

Agriculture and stock raising	14
Architects	24
Artists	4
Banking	7
Bookkeepers, general assistant and clerks	153
Cashiers	5
Chemists	9
Contractors	2
Dentists	4
Draftsmen	100
Electricians	19
Fieldmen	4
Foremen in manufactories	3
General managers	32
Insurance men	9
Lawyers	30
Librarians	1
Mechanics	14
Merchants and manufacturers	90
Ministers	1
Physicians	22
Real estate	18
Reporters	2
Salesman and agents	41
Students in higher schools	75
Superintendents of manufactories	44
Teachers	39
Technical engineers	65
U. S. Navy engineers	4

Miscellaneous	15
Unknown	56
Number of graduates who have entered elsewhere upon higher education of some sort and have already taken degrees	159

This outcome suggests an important function of a secondary school which I have not seen clearly stated. The secondary school should enable a boy to discover the world and to find himself. I use the word "discover" in the sense of *uncover,* that is, *lay bare* the problems, the demands, the opportunities, the possibilities of the external world. A boy finds himself when he has taken a correct inventory of his inherited and acquired tastes and capacities.

If the secondary school shall do these two things it will do what generally has never been done at all. This cannot be done with a single curriculum, along any line. All your windows and doors must be open. This is a superb function of the secondary school, and every pupil should stay in school till he has secured the benefit of it. Nothing in education can outweigh the importance of these two discoveries: the external world, and one's self. The elementary school comes too early, and the college and real life come too late. The secondary school is the place for discovery and intelligent choice.

When the whole boy has been put to school three or four years in a secondary school he finds out what his strong points are, if he has any, and he works into the occupation where he is most likely to achieve success. In point of fact the round plug gets into the round hole, and the square plug gets into the square hole, with an

infinite sense of compatability pervading both plugs and holes.

While I plead for the neglected majority and point out the glorious opportunity of the secondary school, I must speak a word for the benefit of the minority.

The great mass of American teachers has as yet no adequate conception of the fine invigorating effect of a correct system of manual training upon the mind and character of a healthy, normal boy. I do not refer to manual training falsely so-called; to the wishy-washy tinkering with tools and materials, where the child is the victim of his own whims, and of his teacher's ignorance; where under the pretence of developing originality, initiative, altruism, or concrete expression, the child is prematurely misled, misdirected, and mistreated, until the possibility of well-timed and well-regulated manual training is utterly lost. I regret that I must speak so strongly of a tendency to utterly emasculate manual training by a method of treatment which would be instantly condemned if applied to any other branch of study. We must, I suppose, excuse a great deal of sentimentalism and extravagance on the ground that the most recent converts are apt to be unbalanced by excess of zeal.

Manual training furnishes many of the elements of culture and discipline which are lacking in the ordinary secondary course of study. Contact with the concrete; clear concepts of materials, forces and instrumentalities; exact knowledge of mechanical processes; analyses of complex operations; the idea of precision; habits of system; of foresight; and of intellectual honesty. These mental, moral and physical elements are invalu-

able, and it is not strange that President Eliot said: "Manual training not only trains the eye and hand, but develops the habit of accuracy and thoroughness in any kind of work. It develops the mental faculties of some boys better than books do." Professor James of Harvard says that, "The most colossal improvement which recent years have seen in secondary education lies in the introduction of manual training." And Dr. Stanley Hall says: "No kind of education so demonstrably develops brain as hand training."

The minority should have a chance at this improvement and should enjoy these benefits most assuredly. So here is another splendid opportunity for the secondary school.

EDUCATIONAL VALUES AND OUR LIBERALITY IN MODERN EDUCATIONS.

BY ROBERT H. THURSTON,

Director of Sibley College, Cornell University, Ithaca, N. Y.

The nineteenth century was a "wonderful century" to every student of its evolutions and its developments, whatever his field; in fact, the farther from his own department of work the development is studied, as a rule, the more marvellous the aspect of the unfolding buds of modern life and growth. For many centuries, uncounted generations, the work of the world had been just sufficiently fruitful to permit a new generation to fill the place of the old without retrogression and with here and there some minute advance. China had thus stood torpid, for thousands of years, except for the movement, unimportant industrially and sluggish morally and intellectually, produced by the spread of the later religions. Of India the same story must be told; the same is true of Egypt except for the sowing of a vitalizing and fruitful seed some two thousand years ago by the Greeks of Alexandria. Greece alone, at that time, and Rome almost alone, a little later in our chronology, took useful part in the sowing of the seed and the cultivation of the harvest.

It was only when, about the beginning of the nineteenth century, these slowly germinating seeds opened with almost explosive rapidity and marvels of the new century succeeded each other with startling, con-

fusing, and always accelerating development, that the most philosophic and learned men of the time began to realize the character, the extent, and the tremendous energy of this phenomenon.

With the beginnings of exact measurement of phenomena and of material things in the early part of the seventeenth century and the laying of the foundations of exact science, the modern forward movement began to assume an observable acceleration. With the inventions of Watt and his contemporaries and successors at the close of the eighteenth century and beginning of the nineteenth, the sympathetic flow of all the currents of modern development was initiated and civilization entered upon its most extraordinary epoch. Since the commencement of the nineteenth century, progress has been in all directions and in every department so great, so universal, and so rapidly and steadily accelerated, that every student of history and every economist is amazed by this unforeseen and surprising change in the course and flow of the stream of human life.

Yet, on examination of the manner and the method of this new development of civilization and the industries, it is readily discovered that it comes of the interesting, yet natural, coincidence of two great fundamental and essentially social movements; through invention, the grasping of the forces and energies of nature and the directing, for the first time in the history of the world, of her mightiest power, thermal energy, and her largest resources, our fuel-beds, to the purposes of the industrial system and through the new liberty which permitted the application of the intellectual forces of the time to the revelation of nature's laws and proc-

esses and to the observation and utilization of the facts and phenomena of the natural sciences and their relations to familiar things.

The result of this union of forces was seen in an immediate acceleration of all progress. The scientific method stimulated the rapid and steady development of the arts as well as of the sciences, and even education took on the logical form.

A new education was no less essential to progress than a new and more efficient system of sciences and of industrially applied sciences. The new philosophy and the new learning could only persist and could only advance through systematic instruction of the coming generations of men of science, of inventors and of industrialists. A new learning was the necessary keystone of the new arch, now supporting a new civilization. The modern structure was to be mainly new in its every part. So tremendous a development of the sciences and the arts could only be sustained by a correspondingly complete and effective extension and improvement of the whole curriculum. Modern life needed, as a primary and fundamental element, the modern and various educations and a general system of utilization of these educations through the one efficient principle just revealed by science itself—that which dictated first the discovery and exact appreciation of fact and then the detection of those laws of nature which determined the relations of phenomena and the codification which gives us a science. Education has thus been gradually assuming the form of a science just as truly and just as completely as geology, botany, or applied mechanics.

The new educational system covers every field in which systematic instruction can be formulated and illustrated. The scientific method in education is found to apply to the teaching of youth in physics and chemistry, in the ancient languages and literatures, in mathematics—the elements of all the arts as well as the highest departments of the pantology. We are now learning that, in place of the one education of our fathers, there are many educations and that the educational values are not absolute and positive but are various and relative. We see new reason to agree with Paley in his proposition that education should prepare the man "for the sequel of his life." We discover at once, this being admitted, that educational values, high for one man, are low for another. The statesman, the educator, the engineer and the man of business, the artisan and the agriculturist, while one and all may desire or may need for the leisure part of their respective lives what we may call, following the conventions, a "liberal" education; each needs, as a fundamental necessity and primarily, thorough instruction in the essential principles of his industrial life. The nation can only be in highest degree prosperous when each individual citizen is doing his part steadily, skilfully and efficiently. The individual can only do his work efficiently when he has been well instructed in the principles which govern it, the scientific methods which accomplish most and the details of his art, so far as developed, and in such manner as will make his physical and mental powers most effectively utilizable in his task and most thoroughly effective, in combination with those other individuals and that mechanism which to-

gether—man and mechanism—constitute the industrial system. The man must, in order of necessity, first be wise in his art, he then may make himself and his children competent to profit by further and "liberal" education. For the average citizen, the highest values in his education are attributable to the utilizable forms of learning.

The education of the people is one of the inventions of the nineteenth century and one of its most, if not the most, important and fruitful. The discovery that there should be many educations was a hardly less important event. It was seen that these educations should offer, as completely as practicable, to "all sorts and conditions of men" opportunities for, first, the elementary training needed by all, second, the forms of secondary training needed by the great mass of the nation, by its people of moderate means, and, thirdly, the special scientific preparation for the "sequel of their lives" most needed by those who are to take part in the operation of the industrial system. Finally, we have found that the preparation for the professions of a small body of comparatively strong men, intellectually and morally, is simply a division of this work of preparing a people to do its most and best in advancement of its own progress in the arts, the sciences, the literatures and the culture of the time; thus promoting good manners, good morals and content.

The learned man and the learned profession at present cannot be claimed to represent, as in olden times, all the literatures and languages, all the sciences and all the arts of the time. No human mind could grasp or any brain retain all true learning. He is to-day

learned who has a large knowledge of some one department of the pantology, that in which he professionally lives, and who also has made himself competent to understand and appreciate the talents and learning of the other varieties of learned men with whom he may be brought in contact. He may be learned as a "professional" specialist, as must be all men who seek professional advancement and ultimate success, or he may be learned in departments of pure science, ancient literature, arts interesting the antiquary and the archæologist. With a mind stored to the limit of capacity of the best of human brains, he is a learned man, whatever the fields of knowledge in which he may have gleaned. Thus, to-day, theologians, physicians, lawyers, naturalists, statesmen, engineers; all meet upon the loftiest plane of learning and each recognizes the merit of the other in the great republic of learning.

The outcome of our inventions and discoveries and improved methods in education has been the advancement of learning in a manner quite comparable with our progress in the arts and sciences. We are producing—rather we are permitting them to produce themselves—varieties and numbers of learned men undreamed of a generation or two ago. Huxley's "freaks of nature" are being discovered in increasing numbers; men of talent and capacity rise out of the ranks on all sides and our political and social freedom and our industrial independence have been prolific of opportunity to thousands of otherwise obscured and unknown natural leaders of men. Defining the learned man as one who has talent, capacity, and a mind well-stored in exceptional degree, we find the species in all depart-

ments of life and amongst all the professions. The ancient monopoly of earlier convention has gone.

The "educational values" obviously must now be assigned in the light of modern evolution and progress in the work of education. For the people, the educational values of the constituents of the older curriculum are relatively small; those of the later school for the people, large, absolutely and relatively, are to the people of value beyond estimation. Nevertheless, the former remain of high value to the same class as formerly, to the youth who expects to lead a life of scholarly leisure and to the members of some of the professions. There are thus evidently two scales of measurement of those educational values; much as there are two scales of measurement of the value of common and of "noble" metals, or of bricks and of "precious" stones.

For the average citizen, brick and iron have higher real values than gold and precious stones. For him a world without the materials whose values are conventional would be just as satisfactory and its wealth just as ample and desirable. The values of the metals, the foods, the materials of agriculture and mining generally, are real and relatively definite and comparatively exact. The values of the luxuries are conventional and inexact; for, in fact, the world would not be aware of its loss had they never existed; while none of the necessaries of life could have failed without injury to the race.

Similarly in education. The educations of our public schools, of the trades, and of the professions, are the brick and iron and steel of our fundamental intellectual

world; the educations of our academic colleges and universities of the ancient type are largely the gold and the precious stones of that world. Thus the needy place house and land, home and food and shelter at the higher extremity of the scale which marks maximum value, and rates low the comforts and luxuries of the man of leisure, placing his gold and his diamonds and his *articles de luxe* generally near the zero mark; while his more fortunate brother pays out a fortune for a picture and a poor man's income for his wine or his cigars. The fact is thus evident that, not only do these values vary with circumstances, but the valuer himself shifts his place in the world.

The changes which we have been witnessing in our educations since the days of Francis Wayland mark changes in the position of the valuer. It is not that the various educations of the rich and of the poor, of the scholar and of the professional, were not recognized earlier. Milton and a score of other great thinkers saw these distinctions and urged their general utilization in earlier days and the Ptolemies twenty centuries ago, and probably the old "House of Seti" and that of Rameses, a thousand years and more before Alexandria was founded by educators using the "modern" scale of measurement of values, illustrated this larger liberality in education, only lately expressed in the sentiment of Ezra Cornell: "I would found an institution in which any person may find instruction in any study." The particular and fundamental fact is that we are, for the first time in the history of the world, adopting in measuring educational values, the scale of measures which is recognized by the people who are,

for the first time in the history of the world, permitted to profit by a general and a public, a common-school education. All modern educational systems are illustrating the evolution of these various types of education for various types of citizen, and educators are adapting themselves to the requirements of the people rather than wholly to the demands of the leisure classes.

While the needs of the humblest are coming to be satisfactorily met, the requirements of the people of moderate means, of the well-to-do and of the wealthy, are better met than ever before. Precisely as in the industries, modern civilization is bringing to "all sorts and conditions of men," and of women as well, those things which each desires and in larger and larger quantity, in better and better quality, and at lower and lower cost.

Educational *valuations* have thus changed greatly within the last generation and yet the intrinsic value of either type of education remains unaltered and each suffices just as satisfactorily for the individual seeking it. Our intellectual, like our industrial world, has widened, deepened, and gained in the richness of its life. Retaining what was good of the old, it has added inconceivably of new riches and in their accessibility to the people. Our ideas of relative, as of absolute values, in the mental as in the material side of life, have changed; but the brick and the gold, the iron and the steel and the precious stones are all still to be found and still to be had, by those who most want them, and uncounted new and valuable and desirable things are constantly being added to the available store through-

out the whole range of conventional and of actual values, from common earth and a kindergarten to gold and precious stones and the highest education of our professionals.

Learned men are now found in all the professions as well as in all the schools. The learnings of Bacon and of Newton, of Rumford and of Watt, of the philosophers, the men of science, the engineers and the theologians, the men of the law and the medical men, are all to-day admirable and admired and prized. The republic of learning comprehends in one great democracy men of letters, men of science, men of the professions and men of studious leisure. All the educations of the citizen for the life and work of the citizen of the republic are provided as needed and educational values are fixed by the wants of the class of individuals needing the educations. The tendency has come to be more and more distinctly toward the production of learned men in all departments and the elevation of all men thereby. As educational values become established in accordance with the ideals of Paley and of Milton, all classes will share learning, and wisdom and culture will become more widespread.

This is a movement leading toward the greatest prosperity, the highest civilization, the truest happiness of the nation.

THE ORGANIZATION OF TRADE AND ELEMENTARY TECHNICAL SCHOOLS.

BY ARTHUR L. WILLISTON,

Director, Department of Science and Technology, Pratt Institute, Brooklyn, N. Y.

I think that all persons will agree that public education should, in a general way, reflect the spirit of the age, and the life of a people. In all history, there never has been a time when industrial activity and the application of scientific principles to the arts has so pervaded almost every community, as at present. Our country has recently been undergoing stupendous change in this direction, the magnitude of which few persons realize, producing effects that have been accumulating ever since the substitution of mechanical power for hand power became general, nearly half a century ago. The number of those employed in mechanical occupations has greatly increased during the past ten or twenty years, and the occupations themselves have increased in variety, and in the demands that they make upon the men engaged in them—a larger and larger proportion each year—requiring the exercise of nice appreciation, real intelligence, and often a thorough understanding of many of the simple principles of science, from those who would fill them acceptably. As a result of these more exacting requirements, we hear everywhere of the difficulty of getting competent workmen; and the testimony that it

is growing more and more difficult to secure them goes unquestioned. This is not because the men available are not as intelligent as formerly, for there never was a time when the mechanics of this country were as intelligent as they are to-day. Our national progress in manufacture and the arts proves this. It is simply because the means of training our workers has not kept pace with increasing demands that present-day conditions are placing upon them. To-day, one fourth of the entire population of the United States, having any regular employment, finds it in the building trades, in manufacturing, and in similar mechanical pursuits; and in Massachusetts and the North Atlantic States the proportion of those thus employed in mechanical work is much larger even than this average of the country at large, being 46.9 per cent. and 34.6 per cent. respectively. The demands too are more exacting, yet here where the school system is best organized and developed, it has not thus far expanded to meet these needs, even though they have existed for more than a quarter of a century, and are growing more urgent every day.

As a nation, we have long cherished the idea of having every boy and girl in the land receive at least a complete elementary school training. I wonder how many of us appreciate how far short we actually come from realizing even this modest ideal. Less than one third of all the children who enter the schools in the United States ever graduate from the grammar school, or its equivalent; and not one eighth ever go further than this in their school work. On an average, American boys and girls now receive only a trifle over the equivalent of five years, of two hundred days each, of

school training; and for every one who receives eight years, or the complete elementary school training, there is another who receives but two years, or three others who receive but four years of school training. Three fourths of them all start their life work with almost no education, with nothing but the most meager knowledge of reading, writing, and arithmetic. I think that perhaps our attention has been so centered on the growth and progress of the high schools and the colleges that we have not been conscious of these facts, nor have we realized what a small percentage of the entire enrollment these more advanced schools reach. 94.35 per cent. of the total school enrollment is in the elementary schools; but 4.25 per cent. is in the secondary schools; and only 1.4 per cent. is in higher institutions of learning. These last two figures show a very remarkable increase over the corresponding figures for a few years ago, but the per cent. of the children of the United States enrolled in the elementary schools during the past twenty-five years has remained practically constant. Nor is it appreciably higher in those states that are conceded to have the best schools to-day, than it is, averaged over the country as a whole.

In at least two important particulars, therefore; in the failure so to expand as to reflect the mechanical and scientific spirit of our times; and in the failure to educate and train the whole people, the common schools of the United States have failed in what the nation has expected of them. Nor is this failure offset or made the less real by their brilliant success and achievement in other directions. I do not wish to criticise nor to appear to underestimate the value of what the schools

have accomplished, and I thoroughly appreciate the high standard that they have attained in most of our towns and cities; but my work for the last ten years has brought me in contact with a class of individuals for whom the existing schools are able to do little, and each year I have come to feel their needs more keenly, as I have seen and understood how real these needs were, and what it was possible to do to meet them.

I believe that it is worth while asking whether our plan of popular education cannot be so extended as to aid further the vast horde of individuals who do not now share its advantages beyond the most elementary grades.

First, however, let us inquire into the reasons for pupils leaving the public schools in such large numbers so early in the course. No doubt, here, many causes combine together and perhaps combine in different ways for different individuals, but in a great majority of cases three causes stand out clearly. A few children leave the schools because for them progress is absolutely impossible; a larger number leave because the fierce human struggle for a livelihood makes it absolutely necessary for them to face the problem of self-support at once; but the largest number, I am convinced, leave when it is not absolutely necessary—when they or their parents could with some sacrifice keep them in school, and would willingly do this for another year or perhaps two or three years if they believed that it was thoroughly worth while. They leave because after careful reflection they and their parents do not think that the additional year or two of school would help them in the competition that they will meet in life

as much as making an early start or if it would, the difference in favor of the school is so slight that it does not seem to them to be worth what it costs. It has been a continual surprise to me, as I have come in contact with many of the most uneducated American boys and their parents, in various investigations that I have made, to find how almost universal is the answer to my inquiries that they would willingly have made the sacrifice necessary for another year or two at school if the boy could have gotten a training which would have been of some direct practical benefit to him in the trade or occupation in which he had decided to engage. It is not wholly poverty that causes over 85 per cent. of all children to be withdrawn from school upon the completion of the preparatory school course, even in prosperous years. It is quite as much, I believe, the conviction that education, which does not help toward efficiency in one's life work, at the same time that it ministers to breadth of view, is a luxury intended only for a few, rather than a necessity for all. When the American people pass this judgment by such an overwhelming majority, it is, to my thinking, time we seriously considered what may be done to make our system of popular education in reality a system for the whole people.

The remedy, it seems to me, is most apparent. We need not alter our existing schools, but rather supplement them with others that will meet the needs of those who are at present unprovided for, as squarely as the present high schools meet the needs of those preparing to enter college, or as the professional schools do for the doctor, the lawyer, or the engineer. The idea is not

new in this country. The Lowell Textile School, The Williamson Free Trade School, near Philadelphia, the New York Trade School, the Pratt Institute, of Brooklyn—the institution which I myself represent—are examples. Some of these have been in existence for fifteen or twenty years—all of them long enough to prove beyond question their value from every point of view. In Germany the idea is older, or, if not older, at least it has received more general adoption. In Berlin, for example, in 1901, 55 per cent. of all of the boys in the city between the ages of fourteen and eighteen years were enrolled in evening schools of this practical character, in addition to all those who were enrolled in the trade and elementary technical schools during the day.

To have our system of popular education in the United States effectively reach the great mass of wage earners, we need, in my judgment, to organize at least four types of schools to supplement the existing schools, or a single school to embody the four distinct types of courses of instruction.

First. *Day Trade Schools* of a very practical character where young men to whom another year or perhaps two of school is possible, can acquire a technical skill and efficiency in any one of a very large variety of trades, which will give them immediate help in securing profitable employment, and so ground them in the principles underlying their work that they may hope soon to become intelligent and skilled mechanics.

Such schools may not aim to graduate finished mechanics, but they can turn out advanced apprentices, trained in method, understanding the relation between cause and effect and the simple principles of science as

applied to their work, full of ambition and skilled enough to make them sought by employers. In the short time available, what type of education could hope to do more?

Second. *Elementary Day Technical Schools*—for those who can devote the necessary two or three years after completing the elementary schools—to teach the applications of science and art to all manner of industries.

The Lowell Textile School is an example of this type of school. It is well known that the truths and methods of modern science are immensely helpful to the leaders in the industrial world, but it has also been demonstrated that, if taught rightly, they are no less helpful to the men in the ranks. These two types of schools will have a very large enrollment from those who otherwise could receive no further educational advantages.

Third. *Evening Trade Schools* for those to whom further education during the day is out of the question —and the number of these will always remain very large—to give them the practical skill necessary to enable them to become skilled mechanics and intelligent workers in the large number of trades in which they are employed during the day.

The courses of instruction in these schools should embrace even a wider group of trades than the day trade schools. They should include not only the usual building and manufacturing trades, but also such trades as that of the upholsterer, the tailor, the lithographer, the engraver, the watch repairer, and many others besides.

Fourth. *Evening Technical School* for young men of greater intellectual capacity than those included in the evening trade schools who are employed as skilled workmen, draughtsmen, clerks and the like, who wish opportunity to study those technical subjects which will help to broaden them in their various lines of work and give them instruction in those branches of applied science or art which are directly related to their several callings.

The courses of study here should include among others such subjects as practical mathematics, technical chemistry, physics, applied mechanics, applied electricity, machine and architectural drawing, and applied design related to many crafts and industries.

In these schools as I have hastily outlined them, I have referred only to the needs of men employed in mechanical occupations, but it is my thought that they should also provide courses of instruction leading to every well-defined vocation in which there are a sufficient number of either men or women employed, to make their establishment sought. I believe too that all four of the classes of schools that I have described should be highly specialized, differing in the courses of instruction that they offer in different places, according to local industries and the principal occupations of the people.

The practical advantage that would be derived from having trade and technical schools, with day and evening classes generally established throughout the land, would be almost beyond calculation, but their educational benefit in the development of intelligence, manhood, and good citizenship would, in my judgment, be

still greater. The demand for such schools is unquestionable, and at present in most places the only way in which this demand can be satisfied is through correspondence schools, which to-day enroll more students than all the colleges and professional normal schools in the United States combined. The large majority of these students are mechanics and laborers, and to me it is a sad reflection of our national system of education that the earnest pleading for knowledge on the part of the wage earners of the land has become a profitable field for business enterprise.

In describing what may be accomplished through these schools, I am not speaking without knowledge. I am speaking from experience of over ten years in this field of education, where I have seen young men under my charge grow and develop intellectually in a way that would surprise most teachers. I have seen evening classes in elementary mechanical drawing with but six hours per week for twenty-four weeks do work that I would willingly compare—every member of the class—in quantity and quality of work, with that of any college in this country in thirty-six weeks of the same number of hours per week; or with almost any high school in twice that length of time. I have seen evening classes in technical chemistry with fewer hours per week surpass day students who had much better preparation and training. I have seen young apprentices with instruction equivalent in hours to only three weeks' work at their trade, do things that journeymen mechanics with four or five years of experience cannot equal—and these things are not unusual or exceptional. They make one have faith in what patience and perseverence

and determination can accomplish. They have taught me to believe in the young men who come to the trade and the technical school for help, and if every one of you, present here to-day, had had the same opportunity to see them and to know them you would believe in them too. In theory, we all of us agree that it is from the great class of the people who work with the hands that the flower of the nation comes, when given half a chance, but in the present state of our social development, the means for them to rise have been largely cut off, and to-day they sadly need the stepping stones the trade and technical schools would afford them.

Some persons fear the attitude of organized labor towards these schools, but my experience leads me to have confidence in its support. All unions of skilled labor desire to restrict admission to their ranks. And they are wise and right in wishing to make this restriction as rigid as they can. Every professional organization does the same. No lawyer can practice in this state until he has passed a difficult examination at the bar, and no engineer can obtain any business until he has finished a thorough course of training or completed an apprenticeship of practical experience even more severe. The members of the unions realize that their power and their safety comes from having the gap between skilled labor and the unskilled just as wide as possible, and any agency that will help to widen this gap by making skilled labor more effective and efficient, they will welcome, for they understand that with them, just as much as with the doctors or lawyers or engineers, the only lasting and effective restriction is that of education and ability. They will oppose any school

that seeks to turn out large numbers of half-trained men, who will tend to lower their standard of average ability and capacity—and rightly; but I think we can safely trust the good judgment of the American workman to see in the schools such as I have described that help to lift and uphold the standard of his trade the most potent aid and ally that has been offered him.

If, however, these schools are to realize their possibilities, those who organize and direct them must appreciate the fact that they can only succeed by supplying the needs of the people who are taught, and not by giving them something else which is believed to be just as good or perhaps better for them. The teaching of the industrial classes is not difficult if it is commenced at the right end, by going down among the workers and finding out what they actually need to make them more efficient. The methods of teaching must be adapted to the people taught; conventional methods will not answer. The teachers must be men who know those whom they would teach; who are chosen because of their enthusiastic belief in their work; who have unusual skill and proficiency in their particular calling, and who are such masters of their craft as to command respect from all who are competent to judge.

The equipment, too, in all practical lines of work must be modern and the equal of that found in the best plants of the same character; for the students will judge the standard of instruction largely by the standard of the things that they can see and are familiar with. But the greatest essential of all is directness and singleness of purpose in all the work. If the object is to help a certain group of individuals in a practical way, they should be told so frankly, and then all ener-

gies devoted to the accomplishment of that one aim. To deviate from the object for which a course is planned will decrease confidence in the sincerity of the school, and everything which is not in the direct line of giving the students the exact kind of practical help which they seek in the courses of instruction which they enter, will be found to be detrimental. It may sometimes seem as though more good could be accomplished in the direction of general culture and good citizenship if something specific were introduced into the course for the accomplishment of this end, but I think that it has been demonstrated beyond a doubt that by helping young people to help themselves in a practical way, through such practical means as I have here tried to describe, more is actually accomplished in the way of character building and the development of citizenship than could be done in any other way.

The time is too short to accomplish more than one thing well, but it is not too short to give these earnest workers just the help that they need, and, in giving it, to show them a goal worthy of their best ambition, which they can reach if they will continue to apply through life the same scientific spirit that they have used in their school work: First, the belief that there is more truth and a better way than they have ever found that is worth their striving for, and, second, faith that if they apply all their knowledge and experience towards finding it, then they will succeed. It is this faith will give enjoyment to toil, and what greater blessing could a nation bestow upon the multitude of people who must spend the greater part of the waking hours of their lives in working with their hands, than an opportunity to learn to do their work in this spirit?

REPORT OF COMMITTEE ON TECHNICAL BOOKS FOR LIBRARIES.

In 1901 a Committee of seven members was appointed to prepare a list of books on applied science and technology suitable for the use of libraries of various classes. The task assigned has proved to be a difficult one on account of the great amount of work involved and the lack of suitable coöperation of the various members of the Committee, which is most difficult to secure through correspondence.

The report which your Committee presents at this time is the result of two years' attention to a task which can never be completed, and it is to furnish a working basis for further addition and revision that the accompanying list of books is recommended.

The first work undertaken by the Committee was an investigation of the present conditions in public libraries as regards equipment of technical and scientific literature, and also the extent of the demand for the list of books which it was the purpose of this Committee to prepare.

It has been found that a comparatively small number of libraries have paid much attention to the science and technology department, and in the great majority of cases, the books contained in this department have been ordered as a result of popular demand regardless of their suitability for the readers. The defects which would naturally arise as a result of such methods of choice are notable.

In the larger cities and especially in industrial centers, a different condition of affairs exists, a considerable amount of attention being given to technical and scientific matters, and in some cases with satisfactory results. A number of such libraries were visited, notable among which are the Model Library at Providence, Rhode Island, and the Carnegie Library at Pittsburg. In these libraries the technical and scientific departments are in charge of experts and their collections of books along the lines in which we are interested are very creditable.

The chairman attended the Boston-Magnolia meeting of the American Library Association last year and presented a paper dealing with the choice of scientific and engineering books for public libraries. The interest shown in this matter both in the meeting and as a result of conversation and correspondence with many librarians shows, that there is a very decided demand for an evaluation of scientific and engineering literature by competent authorities. A number of libraries have taken steps in this direction in employing technical men to assist in the selection of books, but even this has not led to satisfactory results, due partly to the neglect of the elementary and popular literature and partly to the inclination of an expert to balance wrongly the list by attaching too much importance to the line in which he is particularly interested. The question of suitably balancing the list among the various lines of engineering is a difficult matter, for it must be done not only with regard to the relative industrial importance of the various lines, but also in accordance with the public demand and local conditions.

The Committee undertook the task of examining the available literature with the purpose of evaluating it from the library standpoint. The members of the Committee, representing various lines of engineering, were naturally acquainted with leading advanced engineering books, but were less familiar with the books of a popular and an elementary nature. This necessitated a careful examination of a great many such books which are not commonly found in our university and personal libraries, but which are very important from the standpoint of the public libraries.

As a result of the examination of many hundreds of books, the accompanying list of about three hundred and forty titles has been compiled. The books chosen are classified into twenty-five divisions in accordance with the various lines of technology, and also into four divisions in accordance with the classification of readers which they are to serve. These classifications are given on page 62 of the accompanying list.

The Committee recognizes various limitations and defects in the list here presented. A relatively small number of elementary and popular books are included, a class of literature for which there is a great demand in the libraries. The limited number is not the result of insufficient attention to this matter, but rather of the fact that a comparatively small number of such books that can be recommended, exist. Unless an elementary book is accurate in dealing with the principles of science and engineering, it is worse than useless, even though of great interest from the popular standpoint. This characteristic of the elementary book is what reduces the number of desirable ones to a very

limited quantity and makes the A-B-C class of literature as a rule undesirable.

Another characteristic of our list is that American publications very largely predominate. This fact was not a result of intent to exclude foreign publications, but was incident to the choice of works most suitable for our American readers. Books written in foreign languages have been omitted, and a more extensive compilation which might be taken up in the future should undoubtedly remove this limitation.

Another marked limitation of our list, and one which should be corrected if it is to be developed further, is the lack of works relating specifically to the various industries. Your Committee had proposed to develop this feature, but the limited time which the Committee has had at its disposal made it impossible. The list should include books relating to the various industries such as cotton and the textile industries, tanning, brewing, the ceramic industries, manufacture of soaps and chemicals, etc.

It is believed that the list of books here presented may be of assistance to the many public, industrial, and school libraries as well as to our engineering graduates and others who may wish to be informed as to the best literature relating to various branches of engineering. It may well serve as a basis for further development and improvement should our Society or others desire to continue the work.

C. F. Burgess,
Chairman
for the Committee.

INDEX.

The publications in this list are designated by the letters *A, B, C,* and *D,* to indicate something of the nature of the books and the class of readers for which they are particularly suited. The classification is as follows:

A. Books of elementary nature containing no mathematics and written in the simplest form; for boys, amateurs, and others having no previous knowledge of the subject.

B. Books treating the subject from the popular standpoint and written in such a manner as to be of general interest.

C. Books treating of details of practical application of science and engineering; suitable for city officials or others interested in municipal affairs, manufacturers, mechanics, artisans, students in manual training, and as preparatory for more advanced work.

D. Representative advanced book for engineers, designers, surveyors, etc.

REFERENCE LIBRARY.

Periodicals:

Cassier's Magazine, New York	Monthly	$ 3.00
Engineering, London		9.00
Machinery, Providence	Monthly	2.00
Marine Engineering, New York	Monthly	2.00
Marine Review, Cleveland	Weekly	3.00
Power, New York	Monthly	2.00
Scientific American, New York	Weekly	3.00
Scientific American Supplement, New York	Weekly	5.00
The American Machinist, New York	Weekly	4.00
The Engineer, London		9.00
The Engineer, Chicago	Monthly	2.00
The Engineering Magazine, New York	Monthly	3.00
Cement, Chicago	Monthly	2.00
Stone, New York	Monthly	2.00
The Draftsman, Cleveland	Monthly	1.00
Steam Engineering, Chicago	Monthly	1.00
Ice and Refrigeration, Chicago and New York	Monthly	2.00
Forestry and Irrigation, Washington	Monthly	1.00
The Irrigation Age, Chicago	Monthly	1.00
American Electrician, New York	Weekly	1.00
Electrical World and Engineer, New York	Weekly	3.00
The Electrochemical Industry, New York	Monthly	2.00
The Horseless Age, New York	Weekly	2.00
Engineering and Mining Journal, New York	Weekly	5.00
The Foundry, Cleveland	Monthly	1.00
Municipal Engineer, New York	Monthly	2.00
Municipal Journal and Engineer, New York	Monthly	3.00

Engineering News, New York	Weekly	5.00
Engineering Record, New York	Weekly	5.00
American Engineer and Railway Journal, New York	Monthly	2.00
Railroad Gazette, New York	Weekly	4.20
Railroad Master Mechanic, New York	Monthly	1.00
Railway Age, Chicago	Weekly	4.00
Railway and Locomotive Engineer, New York	Monthly	2.00
Railway Review, Chicago	Weekly	4.00
Street Railway Journal, New York	Weekly	4.00
Architectural Record, New York	Monthly	3.00
Brick Builder, Boston	Monthly	5.00
Engineering Review Heating and Ventilating, New York	Monthly	1.00
Science and Industry, Scranton	Monthly	1.00

Index to Technical Literature: Vols. 1, 2, 3. Eng. Magazine.

Knight's Dictionary.

Various books taken from main list, including engineering pocket books, dictionaries, etc.

Publications of International Correspondence Schools: Scranton, Pa.

	Vols.		Vols.
Shop practice	4	Steam engineering	2
Applied mechanics	2	Electrical engineering	4
Sheet metal pattern draft	1	Civil engineering	3
Chemical technology	3	General chemistry	3
Telegraph engineering	2	Metallurgy	2
Telephone engineering	1	Navigation	2
Locomotive engineering	2	Architecture	4
Marine engineering	1	Mining	3

The above is a partial list of their publications.

Each set is divided as follows: Mathematics, physics and technical branches, and includes a volume of tables and formulas. They are suitable for both elementary and more advanced students.

Each subject is developed from the beginning, commencing with the most elementary mathematics.

When the library offers a place for study, these books would afford ample material for use of students. Satisfactory for reference rather than for circulating purposes. Publications of American Correspondence Schools, Chicago.

1. REFERENCE BOOKS ON SCIENCE.

D. Arrhenius, Svante. A Text-Book of Electrochemistry. John McCree, Translator. Longsman, Green & Co. $3.50.

This work deals with the modern views of physical chemistry.

A. Avery & Sinnot. First Lessons in Physical Science. 1897. Sheldon & Co. $0.60.

Suitable for most elementary work.

C. Cumming, Linnæus. Heat. Longmans, Green & Co. $1.50.

For the use of schools and students.

C, D. Daniell, Alfred. Text Book of the Principles of Physics. Macmillan Co. $4.00.

A comprehensive advanced text-book. Suitable as a standard for reference.

A, B. Dexter, J. S. Elementary Practical Exercises on Sound, Light, and Heat. Longmans, Green & Co. $0.90.

A, B. Gray, Elisha. Nature's Miracles. Three vols. Fords, Howard & Hulbert. $1.80. 1900.

Vol. 1, world building, life, earth, air, and water.

Vol. 2, vibration, energy, sound, heat, light, and explosives.

Vol. 3, electricity and magnetism. Interesting as well as reliable and suitable for elementary study and popular reading.

B, C. Heilprin. The Earth and Its Story. Silver, Burdette & Co. $1.00.

An excellent elementary text-book on geology which

is entertaining as well as instructive. Deals with structure of the earth's surface and the changes continually taking place. Profusely illustrated with fine reproductions and photographs.

C, D. Holman, S. W. Matter, Energy, Force and Work.

ABC. Hopkins, G. M. Experimental Science. Munn. $4.00. 1902.

Elementary, practicable and experimental physics. Descriptions of experiments and mechanical devices illustrating physical principles. Apparatus described so that any one having ordinary mechanical skill can construct it.

A, A. Iles, George. Flame, Electricity and the Camera. Doubleday. $2.00.

A most fascinating book dealing with scientific and industrial progress.

B. Williams, H. S. Story of the Nineteenth Century Science. Harper. $2.50.

2. Reference Books on Technology.

B, C. Benjamin, Park. Appleton's Cyclopædia of Applied Mechanics. Appleton. 2 vols. $15.00.

B, C. Benjamin, Park. Modern Mechanism. Supplementary Vol. Appleton. $7.50.

B, C. Chordal. Letters to the American Machinists. Extracts. $2.00.

One of the most interesting and remarkable books dealing with mechanical matters, and the recommendation that "every machinist should have a copy" is warranted.

C, D. Flather, J. J. Rope-Driving. Wiley. $2.00.

A standard work upon this method of power transmission.

C, D. Goodman. Mechanics Applied to Engineering. Longmans. $2.00.

C. Hasluck, Paul N. Cassell's Cyclopædia of Mechanics. $2.50. London.

A large number of receipts, processes, and memoranda for workshop use.

B, C. Hopkins, A. A. Scientific American Encyclopædia of Receipts. Munn. $5.00.

Over twelve hundred selected receipts dealing with all branches of useful arts.

C, D. Johnson, Professor J. B. Engineering Contracts and Specifications. $3.00.

Includes a synopsis of the law of contracts, engineering specifications, and methods for carrying on the construction of municipal and other improvements. A standard work.

C, D. Kent, William. Mechanical Engineers' Pocket Book. Wiley. $5.00.

Frequently designated "the mechanical engineer's bible." A book of rules, tables, and data for the use of engineers.

C, D. Kidder. Pocket Book. Wiley. $5.00. Last edition.

Best reference book for architects and builders.

C, D. LeConte, Jos. N. Elementary Treatise on the Mechanics of Machinery. New York. 1902. $2.25

A special reference is made to the mechanics of the steam engine.

C, D. Robinson, W. S. Principles of Mechanism. Wiley. $3.00.

B, C. Spon. Mechanic's Own Book. Spon. $2.50.

A useful compilation of suggestions and receipts for everyday mechanical applications.

C, D. Trautwine. Pocket Book. Wiley. $5.00. Eighteenth edition.

One of the best general reference books for engineers.

3. Inventions and Patents.

A. Baker, R. S. Boys' Book of Invention. Doubleday. $1.50.

An interesting elementary book dealing with recent inventions.

B. Byrn, E. W. Progress of Invention in the Nineteenth Century. Munn. $3.00.

History and present status of scientific discovery: not thorough, complete or absolutely reliable, though of value to the general reader, being interesting throughout.

ABC. Cochrane. The Wonders of Modern Mechanism. Lippincott. $1.50.

Recent progress in mechanics, physical, and engineering science described in popular style.

C, D. Cressee, F. A. Practical Pointers for Patentees. Cumberland. $1.00.

BCD. Hutchinson, W. B. Patents and How to Make Money out of Them.

Practical guide for inventors, manufacturers, and business men who have to do with patents.

B. Sutherland, Geo. Twentieth Century Inventions. London. $1.50.

A forecast based upon past experience.

4. MATERIALS.

C, D. Anderson. Strength of Materials. Longmans, Green & Co. Text-books of science.

C, D. Cambria Steel. Published by Cambria Steel Co. Philadelphia.

Very widely used.

C, D. Ewing, J. A. Strength of Materials. Macmillan. $3.00.

C, D. Iron and Steel in Construction. Published by Pencoyd Co. Philadelphia.

Similar to Cambria Steel, with excellent tables.

D. Johnson, J. B. Materials of Construction. Wiley. $6.00.

A standard of reference.

D. Mather. Strength of Materials.

For scientific and technical schools.

C, D. Metcalf, Wm. Steel. 1902. Wiley.

An excellent little work for blacksmiths, tool makers,

machinists, and engineers; dealing with properties and method of working rather than production.

C, D. Pocket Book. Published by Jones and Laughlins. Pittsburg.

C, D. Smith, A. W. Materials of Machines. 1902. Wiley. $1.00

Concise information relative to choice of materials for machine construction.

C, D. Steel, Pocket Companion on. Carnegie Steel Co.

A trade publication containing valuable information for the usage of structural steel.

C, D. Unwin, W. C. The Testing of Materials of Construction. Longmans, Green & Co. $5.25 net.

5. Drawing and Designing.

C, D. Anthony, G. C. Elements of Mechanical Drawing. Heath. $1.50.

This includes a study of the system of projection and the problems arising in designs.

C, D. Anthony, G. C. Machine Drawing. Heath. $1.60.

Application of the principles of projection to the illustration of machinery with practical examples to students and suggestions to draftsmen.

D. Anthony, G. C. The Essentials of Gearing. Heath. $1.50.

C, D. Brown and Sharpe. A Practical Treatise on Gearing. 1896. $1.00.

A. C. Daniels, F. H. Freehand Lettering. Heath. $0.65

Suited for beginners.

D. Durley, R. T. Kinematics of Machines. Wiley. 1902.

C. Hasluck, Paul. Practical Draughtman's Work. Cassel & Co.

C, D. Hiscox. Mechanical Movements, Powers, Etc. Heath. $3.00.

Over sixteen hundred illustrations of mechanical movements and devices; of value to the mechanic, inventor, engineer, and draftsman.

C, D. Klein's Elements of Machine Design. Professor Klein, of Lehigh University.

Good text-book on elementary machine design and projections.

C. Low and Bevis. Manual of Machine Drawing and Design. Longmans, Green & Co. $2.50.

D. Maurer, E. R. Technical Mechanics. Two parts.

Text-book for technical students.

D. Merriman, M. Strength of Materials. Wiley. $1.00.

C. Meyer, J. G. A., and Peker, C. G. Easy Lessons in Mechanical Drawing, etc. Vol. 1, $6.00. Vol. 2, $4.00. Industrial Pub. Co.

A work suitable for home study without teacher; for mechanics and practical men.

C, D. Reinhardt. Lettering for Draftsmen, Engineers and Students. Van Nostrand.

C, D. Reinhardt. Technic of Mechanical Drawing. Engineering News Publishing Co. Reuleaux' Constructor. Translated by Supplee. Philadelphia. $7.00.

D. Unwin, W. C. Elements of Machine Design. London. $2.25.

6. Metal and Wood Working.

A, C. Baird. Amateur Mechanic's Workshop. $2.50.

C. Beale, Oscar J. A Hand-Book for Apprenticed Machinists. $0.50. Browne and Sharp Manufacturing Co.

Hints on the care of tools, explanation of terms, etc.

C. Compton, A. G. Advanced Metal Work, the Speed Lathe. Wiley. $1.50.

A, C. Goss, W. Bench Work in Wood. Ginn. $0.70.

Especially helpful to manual training class.

C. Grimshaw, R. Saw Filing and Management of Saws. $1.00.

C. Grimshaw. Shop Kinks. Henley. $2.50.

A, C. Haslope, L. L. Repousse Work for Amateurs. Scribner Sons. $0.40.

C. Hodgson, F. T. Modern Carpentry. $1.00.

A, C. Holmes, Chas. Course of Instruction in Wood-Carving According to the Japanese Method. London. 1902. $1.25.

A, C. Homer. Practical Iron Founding. Whittaker and Co. $1.75.

A, C. Homer. Principle of Pattern Making. Whittaker and Co. $1.75.

A, C. Lukin, J. Turning Lathes. Whittaker. $1.00.

C. Maire, F. The Modern Wood Finisher. Chicago, 1902. $0.50.

A, C. Marshall, Percival. Practical Lessons in Metal Turning. $0.80.

C. Rogers. The Progressive Machinist. Audel & Co. $2.00

A hand-book for machinists, dealing with materials, gearing, bench and vise work, tools and machines, operation of lathes, and useful tables for the machine shop.

A, C. Ross, G. A. Elementary Course in Woodwork. $1.00.

For use of high schools and colleges.

A, C. Rose. Machine Shop Practice. Two vols. Scribner.

Expensive but has a lot in it.

A, C. Shelley. Workshop Appliances. Science Series.

A, C. Smith, Oberlin. Press Working of Metals. American Machinist. $3.00.

Practically the only work on this subject; interesting and instructive.

C, D. Stephens, W. P. Canoes and Boat Building. Forest and Stream. $2.00.

Complete instruction for the construction of small boats. Illustrated.

C, D. Thallner, Otto. Tool-Steel. Carey Baird & Co. $2.00.

The forging, annealing, hardening, and tempering. Translated by Brannt.

A, C. Wheeler, Chas. G. Woodworking for Beginners. Putnam. $2.50.

"A manual for amateurs containing over 700 illustrations and diagrams."

A. Whitaker, Channing. How to Use Wood-Wooking Tools. Heath. $0.60.
A book designed especially for boys.

7. Steam and Gas Engineering.

C, D. Babcock and Wilcox Co. Steam: Its Generation and Use. New York.
A trade publication similar to The Heine Safety Boiler Company's.

Baldwin. Heating of Buildings.

Carpenter. Heating and Ventilation.

C, D. Clerk. The Gas and Oil Engine.
A standard work of reference.

Durant, W. F. Practical Marine Engineering.

C. Grimshaw. Engine Runner's Catechism. Henley. $2.00.
Describing the principal features of various makes of engines; also, the care and operation.

A, C. Grimshaw. Steam Engine Catechism. Henley. $2.00.
Practical answers to practical questions.

C. Hawkins. Hand-book of Calculations for Engineers. Audel. $2.00.
Dealing with the steam-engine and steam-boiler.

C. Hawkins. Instructions for the Boiler Room. Audel. $2.00.

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25. Biography.

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Beamish. Life of Sir M. J. Brunel. London.
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Deane. George Stephenson. London.
Dickson. Edison, Life and Inventions. Crowell. $4.50.
Glazebrook. James Clerk Maxwell. Macmillan.
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How, Lewis. Eads. Houghton. $0.75.
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Jeaffreason. Life of Robert Stephenson. London. Two vols.
Judson. Field, Life and Work. Harper. $2.00.
MacKay, T. Life of Sir John Fowler. Murray.
Narcourt. Achievements of Engineering. Revell. Chicago.
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Siemans, Werner. Personal Recollections. Appleton. $5.00.
Smiles. Industrial Biography. London.
Smiles. Life of George Stephenson. London.
Smiles. James Nysmith, an Autobiography. London.
Smith, G. B. Lesseps. Allen. 7s. 6d.
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Stuart, C. B. Civil and Military Engineers of American. Van Nostrand.
Thompson, S. P. Faraday, Life and Work. Macmillan. $1.50.
Thorp. Humphrey Davy. Macmillan.
Trowbridge. Morse. Beacon Biographies. $0.65.
Vignoles. Life of C. B. Vignoles. Longmans, Green & Co.
Alexander Lyman Holley. Published by American Institute of Mining Engineering. 1894.
American Enginering Competition. Harper.
Telford and Brindley. London.

Discussion.

A Member.—It occurs to me that if this list were in the hands of members of the Society it might be possible, in fact certain, that individual members of the Society would suggest additions to the list, and I think it entirely probable that individual members of the Society would present objections to some of the books. It seems to me there should be an opportunity for the overhauling of these books. I have had no correspondence with Professor Burgess, but it seems to me that a printed list sent to the members would lead to desirable additions and perhaps to some desirable eliminations.

President.—There are evidently three things before us: (1) What to do with this report as it stands. (2) Will we take any notice of the suggestion that certain books be looked over by somebody else before

being admitted to the lists? (3) Shall the Committee be continued or shall its work be considered for the time being to be well done and the Committee discharged?

Professor Waldo.—Moved report be printed in the Proceedings as a preliminary report subject to revision, and the Committee be continued.

Professor Raymond.—Perhaps it might be wiser to print it as a pamphlet and send it to the membership for suggestions. Therefore, made the motion that it be not printed in the Proceedings until the Society is prepared to endorse it as a whole, which of course it is not ready to do now.

Professor Waldo.—Opposed Mr. Raymond's motion for two reasons: First, because the Society would find out more readily from the Proceedings what has been done than anywhere else. Secondly, if the report is put into pamphlet form it is likely to go the way of all pamphlets and be lost.

Professor Magruder.—Asked Professor Waldo if he would bind this preliminary report as part of the Proceedings? If so, it would have the force of the Proceedings and this might be undesirable if there were objectionable books in the report. He suggested that proof sheets be sent out as soon as possible to some of the members? Let them be returnable in a few weeks.

Professor Emory.—The Society has simply to take the report of this Committee or not, and as such it is part of the Proceedings. The Proceedings are simply the key of these meetings. In justice to the Committee you must print them. We need not accept the report as being the opinion of the Society.

PRESIDENT.—The chair would venture a suggestion that the Committee be at liberty to amend the report previous to publication; that they be allowed to add or subtract anything they may choose to do as a result of any criticism of the proof sheets.

PROFESSOR C. F. ALLEN.—Hoped the Society will always take the view that a report of a committee is subject to discussion and criticism and even attack. He did not think that this Committee desires to take any exception to criticism from the Society. His own personal view, of course, is not the view of the Committee because he did not know what view the Committee takes as a whole, but his personal view is that we want to get at results the best way we can, and if the best way is to put out a preliminary report which will go to members who will criticise it, giving the Committee another opportunity to report to the Society, and then allowing the Society to take such action as it pleases, he would say such method of procedure would be very desirable. Professor Burgess suggests that in particular the publications of the correspondence schools should be subject to discussion before they are incorporated in the report. That the Committee desires criticism is evidenced by the fact that it asks for criticism on one of the points where it has felt that some members of the Society may have decided opinions.

PROFESSOR WALDO.—Thought that the report of this Committee is one of the most valuable pieces of work the Society has done for a long time. It will be valuable to every member of the Society and every member will want a report as soon as possible and in the most convenient form. The most convenient form is bound

in the regular transactions. He hoped that the motion that it be bound in the Proceedings would prevail. We can then take action regarding extra copies of the report which could be sent out as preliminary reports to other persons who are interested, outside of the Society. The Society as a whole is not endorsing anything that is printed in its Proceedings.

PROFESSOR A. N. TALBOT.—Would it not be well to refer the matter of the disposition of this report to the Council to consider it and report subsequently to the Society for final action? He made a motion to that effect, which was seconded and carried.

ENGINEERING EDUCATION FROM THE STANDPOINT OF THE PRACTICING ENGINEER.

BY A. W. AYER,

Mechanical Engineer, Philadelphia, Pa.

Whatever criticism may be directed against the courses of engineering study given by our American schools, there is no escape from the fact that their graduates now fill a very large proportion of the most important and best paying positions open to engineers. Such a condition cannot result from chance or mere good fortune; on the contrary, it has come about because employers have found it to their advantage to employ such men in preference to others who have not received similar training. As these graduates themselves become employers, they turn naturally to the schools for their assistants, and the next generation is likely to find the graduate engineers in full control, from highest to lowest. The technically trained engineer is to-day exerting a mighty influence in the development of the country and its resources and in the future will perhaps play an even more important part. Our engineering schools may well feel proud of the results of their labor, and he will be foolish indeed, who, in the light of what their graduates have accomplished, and are accomplishing, will say that the training which they have given is far wrong in its conception or its attainment.

The practicing engineer is perhaps too close to the activities of industry to get that impartial view and

true perspective which should be his who would speak authoritatively on engineering education in practice. At best he sees but a small part of the field, and is doubtless apt to think that the conditions confronting him are more general than in truth they are. Nevertheless, in his limited field he has an excellent opportunity for observing the measure of success attained by other engineers and by his own subordinates in handling the problems which confront them, and for deducing therefrom an estimate of the comparative value of such differences in training as they may have received. It is with these limitations in mind, and with the deepest appreciation for what our engineering schools are doing that the writer presents the following thoughts regarding some points which in his judgment might profitably be more fully emphasized in the courses of study, and especially in courses in mechanical engineering, which branch alone he feels at all competent to discuss. It seems to him that sufficient account is not always taken of the fact that engineering is a business as well as a profession, and, as a result, that the business side of the engineer's education is too generally too much neglected. The engineer who occupies a responsible position is of necessity more or less a man of affairs. He must do business with business men perhaps quite as often as with other engineers. No faculty is of greater value to him than to be able to see the business side as well as the professional side of engineering propositions as they are presented to him. Many engineers easily develop this faculty, generally much to their pecuniary advantage; some have become recognized leaders in the business world. It is well

worth while for our schools to recognize that there is a chance, even a demand, for engineers in the business lines and to decide what they can do to provide for it.

The writer believes all students in mechanical engineering should be given a course on the principles and practice of cost-keeping. No question is of more vital importance to the proper carrying on of manufacturing processes and apparently few are less understood. Such a course, embodying a study of existing methods of cost determination and of the scope and meaning of the various charges which enter into the cost of the finished product, would be a convenient stepping stone for further study. Let it be shown to the student that other things than raw material, labor, and power enter into the cost of production. Make him acquainted with the meaning and importance of the so-called fixed charges—of superintendence, depreciation, insurance, and the rest. A discussion of the principles and application of depreciation could easily be extended to make a respectable lecture course in itself, while the subject of insurance could hardly be done justice in less, especially if it should be extended to include a study of fire protection and the improving of risks. Such a start having been made in the work, amplification easily and naturally suggests itself. Factory and corporation organization and management, including the piece-work and premium system, business law, the legal status of employer and employee, specifications and the law of contracts, the history of manufacture and possibly other subjects of a similar nature, would hardly fail to arouse the interest of the student or to be of benefit to him when placed in later life in a position of responsibility.

The very natural question suggests itself at this point, of where the room is to be found for the additions to the usual course, which are here suggested, when its present crowded condition is borne in mind, for it is probable that three hours per week for at least one and one half years would be necessary to cover at all adequately this ground. From his own experience in teaching, the writer is fully aware of the difficulties in the way of a satisfactory solution of a question of this kind. Probably such a solution would necessitate either the dropping of certain subjects now taught, or incorporating the suggested changes into an option to be taken only by such students as desire it. It is the writer's opinion that the former course promises the better, and he would suggest in this connection that coöperation and conference between alumni and faculty might bring to light certain differences of opinion upon the value of some of the old standby studies which would serve as a basis of readjustment. It is a pleasure to note that several of our larger schools have already made provision for teaching some of the subjects suggested in this paper, and the writer hopes to see their course more generally followed.

Discussion.

Professor C. Frank Allen.—Before introducing such a course of study as is suggested by this paper, we should apply the test whether the work contemplated by it can be performed equally well outside the engineering college. We should also want to be sure that it will have the proper training value. Whether the amount of time suggested can properly be given

directly to this work seems doubtful. It may be possible however that much that is contemplated by this paper can be secured by modification of the work done in some of the engineering courses now successfully carried on. It is certainly possible in some engineering subjects to give material attention to economic questions, and to take up illustrations which will be useful from the standpoint of the author of this paper, and perhaps illuminate and improve the courses now given as engineering of one sort or another. It is not inappropriate also to suggest that the addition of any new subject of study is somewhat undesirable, for the reason that many or perhaps most of our engineering colleges already have a tendency to carry on too many subjects at any given time.

Professor Caldwell.—It seems to him that in advocating the addition of new subjects to the now crowded curriculums of our engineering schools, one should at the same time state for which of the subjects now taught the new subject should be substituted. All can think of many subjects which might be added with advantage, but it is very hard to decide what should be left out. Some experience along this line came out in the electrical engineering course of the Ohio State University, when the seniors had an opportunity to elect economics. He found that many of the better students seem to feel that they might have as well got this information in their own reading, as by attendance upon class work.

Professor Raymond.—This paper suggests the importance of the work assigned the Committee on Graduation Requirements. He thought every year at these

meetings "Heaven help the poor fellow who studies engineering twenty-five years hence if he is compelled to learn in school all that is here stated to be desirable."

He thought it desirable that engineering students should be instructed in the principles of economics—not what we know as political economy but the difference between first cost and ultimate cost and how to determine costs.

PRESIDENT.—At Washington University they have had, during the past year, a course for about one half year of contracts for engineers, which was exceedingly popular with the students and was felt to be exceedingly satisfactory, and the character of the students was such that it gave him a very favorable opinion of the work. Yet it was in addition to a short course on contracts and specifications.

PROFESSOR DIEMER.—The subject matter of this paper is one which he would endeavor to discuss to some extent at. a later session, but at the present time he would like to say that he agreed positively with the statements previously made, that much work that would help a man in this direction could be given, not as an additional, separate course, but as a supplement or modification of courses already given in methods of construction and in shop work. Personally, he thought that it would not be desirable to attempt the addition or substitution of such subjects in place of anything in the present standard curricula.

PROFESSOR DUNCAN.—It seemed to him that there are two sides to this proposition. In the first place, what is of importance to the student is the possibility of

getting this course, substituting it for something not so important. We want to take something from the already crowded course. And another thing; is the student going to take it? Should it be put in as a special course of study, or should it be given to the general student? Should it be formed as a special course for students expecting to go into factory management—positions in which financial training is almost as necessary as engineering knowledge?

A student must study to learn engineering, but a good engineer will pick up financial training. He had found in his own experience in engineering that business training counts constantly. But financial principles should not be the only ones considered. Subjects of this kind could be sufficiently impressed upon students without the necessity of forming a special course. There are certain things, such as contracts and specifications, which already enter into the engineering course. Subjects such as shop work and factory output are not required by a large class of students, enough to warrant their introduction into the general curriculum. Special cases call for special classes for students.

Professor A. N. Talbot.—Something has been said here concerning the desire of the student to digress from a certain course of study. May we not say that one purpose of training along special lines is that the student may have his attention directed in these lines so that he may afterwards help himself? But the successful engineer must be also a successful business man. It seemed to him that it is rather a question of the way the engineering course is presented at the dif-

ferent engineering colleges. In some schools it is very desirable to present these subjects as special engineering courses; in others, they may be very well covered by courses which already exist.

President.—He had always been a strict opponent of attempting to put business into the lecture-room. Business depends very largely upon features which are temporary. He knew a man who used to spend a great deal of time estimating the cost of every article produced. Costs constantly change and all prices are subject to variation. Even relative values change.

It seemed to him that an engineering school is a place to learn principles that do not change, that it is not a place to learn how a corporation does its business. Students ought not to be misled to learn little matters of this kind. It is more important to present principles which govern all kinds of business and professions. He thought the business man readily comes to know all the little affairs of his own business.

He was opposed and always had been opposed to bringing business into the lecture-room.

Professor Raymond.—He could not speak for Mr. Ayer, and yet he could say quite frankly that he would agree with all that had been said, and yet he would still raise the question as to whether there is not much underlying the student's work, like the laws of production, like the general principles and methods of the relations between employer and employees, and things of that kind, which are just as potent, just as real and just as important as the things which we have been in the habit of including in our courses.

METHODS OF STUDY FOR TECHNICAL STUDENTS.

BY JOHN PRICE JACKSON,

Professor of Electrical Engineering, Pennsylvania State College.

The science of pedagogy as applied to the needs and conditions of the technical student, or the student of engineering—to be more specific—is dealt with at length and in detail, throughout the ten volumes of the Transactions of this Society. It would, therefore, not only be a work of supererogation, but also one of great presumption for the writer of this brief paper to endeavor to present more than a very few suggestions from experience upon the broad subject chosen.

I trust that we are all—considering our professions—believers in the dictum of Herbert Spencer "that the great superiority of science over mere language as a means of discipline is, that it cultivates the judgment." We do not belittle the study of the works of Aristotle, Plato, Thucydides, Cicero, Tacitus, or of any other of the great philosophers or learned men of the past centuries, nor the philosophy or literature of modern times—nay, as a society we commend such study, but do so with the distinct reservation that it shall be not merely for the purpose of adding grace to our language, but also, and primarily, for the development of the power of reasoning and the broadening of the judgment.

We doubtless agree further with the belief of Spencer "that no extent of acquaintance with the meaning of words alone," whether of science or literature, "can

give the power of forming correct inferences respecting causes and effects,'' and that ''the constant habit of drawing conclusions by observation and experiment can alone give power of judging.'' That science properly taught and studied enforces this habit, is one of its inestimable advantages.

Science, and hence engineering, properly taught, is not only excellent food for the mental appetite but is good for the moral man as well. The learning of language or words alone, whether scientific or otherwise, ''tends, if anything, further to increase undue'' or, let us say, unreasoning ''respect for authority. Such and such are the meanings of these words, says the teacher or the dictionary. So and so is the rule in this case, says the grammar. By the pupil these dicta are received as unquestionable. His constant attitude of mind is that of submission to dogmatic authority, and the necessary result is a tendency to accept without inquiry whatever is established.'' Although this idea was expressed by an acute mind in criticism of the dogmatic narrow education of the first half of the century just passed, it fits well with the conditions even of the present day. How many of us have not felt the humiliating experience of having a student accept our word as final and absolute truth? And it may be confidently predicted that not one of the instructors present has failed to hear that a certain statement ''must be true because the book has it so.'' Now, as in past years, the student's lack of independence in mental processes is constantly to be dealt with, and one of our great problems lies in the consideration of the method to be chosen to aid in the development in every man

of a capacity for thinking things out for himself and at the same time cultivate in him a broad and accurate judgment.

The engineering instructor of to-day is unique in being, in greater or less degree, the embodiment of the dream and aspiration of the beacon minds of the last few centuries. The aims and efforts of our schools of engineering were expressed more than two and one half centuries ago by John Milton; who, though surrounded by deep mysticism and unnatural scholasticism, spoke of education in the following lucid terms: "I call, therefore, a complete and generous education, that which fits a man to perform justly, skilfully, and magnanimously, all the offices, both private and public, of peace and of war." Not only did he give this general definition of education, which might so well be the motto of this Society, but he further specified what were to be the aims of the engineering instructors of the latter half of the nineteenth century and the beginning of the twentieth century by asserting that though a man "have all the tongues that Babel cleft the world into, yet if he have not studied the solid things in them as well as the words and lexicons, he were nothing so much to be esteemed a learned man, as any yeoman or tradesman competently wise in his mother dialect only." He further abhors the old error of the university instructor who casts untrained minds into the midst of "intellective abstractions of logic and metaphysics, so that they having but newly left those gymnastic flats and shallows where they stuck unreasonably to learn a few words with lamentable construction, and now on the sudden transported under another climate, to be tossed

and turmoiled with their unballasted wits in fathomless and unquiet deeps of controversy, do for the most part grow into hatred and contempt of learning, mocked and deluded all this while with ragged notions and babblements, while they expected worthy and delightful knowledge." He insists with the other great intelligences of the last few hundreds of years that learning should progress in a natural order as the babe learns to suckle, babble, crawl, make a step, utter a word, and thus by gradual and natural progress build up the knowledge and experience necessary to bear it successfully through life.

Are not the scientific, or better still, the engineering ideals of the day the embodiment, though imperfect, of these thoughts and ideas which have been slowly developing and growing for so many decades or even centuries?

We all believe that an educated man should have judgment; should be able to understand; should think logically and lucidly; should be an expert in at least one field of the world's work, but with a broad and general culture at command; should be able to perform his share of the social duties of humanity; should, during his younger years, have developed so true and avid a desire for knowledge that throughout life he will gather about him the writings of his great contemporaries and those who have gone before and will delight in learning from them; and should above all be absolutely honest and honorable, energetic and industrious, high-minded and of true, steadfast purpose. In fine, we desire that he be so trained as to be a potent force for good in the world.

Having agreed on all these points as essential to the education of a man or more particularly of an engineer, let us step aside and look for a moment into the study-room of the youth. Let us watch him study and observe how he absorbs knowledge from the texts and lectures lying upon the table before him. We may find him deep for the nonce in the study of mechanics; we may see him read a sentence, ponder it, turn to his dictionary still unsatisfied, look up references in other books, turn back to the earlier pages to ascertain the first steps of the problem he is contemplating. We may find him, with brows contracted and face intent, endeavoring to discover why the author inserted a certain word, or why a sentence was arranged in some particular order, and how such and such a statement can be proved if such another statement is to be accepted. Having satisfied ourselves that this man is reaching forth for knowledge in the true manner and spirit and that good service to humanity is assured through him, we turn away and enter unseen the room of another youth who also is engrossed in mechanics. We observe him passing from page to page with great rapidity and at first are convinced that here must be a wonderfully acute and penetrating mind; but alas as we draw closer, we hear him mutter: "I don't quite know the meaning of that word but I can guess it nearly enough," and "I don't quite understand that statement but I will ask the professor about it to-morrow" or again "That statement must come from something that we had earlier in the book, but as it is not in the lesson I will wait until the review before looking it up." This young man dashes our spirits greatly. We think

it probable that he will make a fairly good recitation on the morrow but we are positive that he will never have within his brain a clear and true conception of the laws of mechanics. So we pass from room to room and find a few men like the first, many like the second, a still larger number even more superficial than the last, and a not inconsiderable number who study almost not at all.

On passing through another portal we hear many voices in earnest discussion and wonder among ourselves whether some momentous point in college politics is at issue or whether the "red and yellow" athletic association insists upon playing an illegitimate member upon their foot-ball team; but, no, as we enter unobserved we hear such words as, "moment of inertia," "flexure," "rectangular beam," "box girder," "resilience," "elasticity," "shear," and the like, and thereby know that mechanics even here monopolizes the field. One keen-eyed young man is insisting with vigor and energy that such and such a proposition must be correct, for can you not see that this other statement is true and that that truth was proven thus? Three or four other fellows evidently disagree with our friend and are watching their opportunity to strike a home thrust which he cannot parry. Others sit by smiling and throwing in a word now and then. The fact under consideration was probably as obscure in the beginning to the minds of the youths gathered together, as is the uncut diamond lacking in light to the eye on account of the encrusted layer of foreign matter and the lack of form in its facets. But in the contention of young minds over the facts in hand in such free and un-

hampered discussion, each aspect of the problem must begin to show forth, much as light is reflected from the facets of the polished diamond. Undoubtedly these boys will obtain a clearer and more balanced conception of the subject than can be possible to those who confine their studies to class and individual work alone.

We were much pleased with the interest these boys take in their mechanics and believe that they certainly were possessed of the right spirit.

It is the intention of the writer to-night, having thus touched upon education as we wish it and having looked in upon the student as he is absorbing it, to suggest that the technical student should be led by his teacher to meet with his fellows and pursue a part of his study collectively with them, not however without previously having had firmly impressed on his mind the great importance of sufficient individual effort.

Many objections will be opposed to this idea. It may be said that such instructions from the teacher will lead to the indolent youth obtaining his education by the mere supine act of listening to the speech of his fellows thus congregated together. It may be said with some show of judgment that the student has sufficient opportunity for general discussion, and for obtaining the effect of "multi-contact" with the minds of his fellows, in the class-room. It may be further said that the time thus spent in collective study could be more efficiently utilized in close systematic individual work.

Many in this gathering no doubt will consider these arguments, on first thought, to be logical and true, but let us consider more in detail the facts as they bear upon this important pedagogical problem. In the first

place the lazy man, the unambitious youth, the boy who is inclined to do everything but work, will not prepare his lessons properly with or without opportunities for collective study. Such a youth, therefore, will certainly not be injured by the method of study which I am proposing. Such a boy needs an incentive which will draw him from his lethargy and which will cause him to buckle up the traces of his wagon at least a notch or two, even though he be incapable of hitching it to a star. What is more likely to give the boy the needed inspiration and desire for knowledge and truth than to be thrown into mental contact with the enthusiasm and energetic spirit of his more active and right-minded classmates? Indeed, in the immediate experience of the writer several cases have occurred where young men, originally quite indifferent to their studies, have been brought, largely by means of just such gatherings as have been proposed, to a true understanding of the meaning of their college course and to an enthusiastic interest in their technical studies. Though at the beginning of their third college year the possibilities of education seemed in great measure closed to them, they became, by the time graduation day was reached, respected as among the best men of their respective classes. Thus this method, if not carried to excess, should have a tendency to awaken and uplift the weaker men to better things.

The second objection that sufficient opportunity for controversial study is offered in the class-room may in the case of some studies hold true. But class work, however free and untrammeled, can never become a perfect substitute for the unrestrained intercourse of

fellow student with fellow student. No matter how much of a good fellow an instructor may be; no matter how inspired; no matter how carefully he may endeavor to place himself upon a mental level with the members of his class, there will always remain a line of demarcation. The mind of the student will fail to open with the same freedom and independence before him as among his fellows. The instructor will always remain a sort of arbitrator to whom the problem in hand may be referred for solution and though the discussion waxeth warm many a tongue will be silent which would vigorously urge the standpoint of its owner were the conditions different. You may consider yourself able to throw off all formality; you may be equal to or even in advance of the famous though trite Mark Hopkins sitting upon one end of a log with Garfield on the other, but in spite of your best effort and highest inspiration you will fail at times to cause the budding mind of youth to open while within the restraining influence of your presence. Well must Emerson have known this when he said: "Do not think the youth has no force because he cannot speak to you and me. Hark! In the next room, who spoke so clear and emphatic? Good Heavens! Is it he! It is that very lump of bashfulness and phlegm which for weeks has done nothing but eat when you were by, that now rolls out those words like bell-strokes. It seems he knows how to speak to his contemporaries." The instructor, the class-room, the illustrative apparatus, the books, the very seat upon which he rests, all combine to give the college youth an impression of great learning far beyond his ken and to make him feel acutely his own

ignorance, and the futility of any words he might utter. This feeling wears off more or less but remains poignantly with many a student until he has doffed his undergraduate cap and gown on graduation day.

The third objection that the student can obtain more mental training through individual study than collectively is probably the most difficult one of all to meet. If the instructor uses poor judgment and permits his boys to neglect a due and proper amount of individual grinding the criticism undoubtedly stands valid. On the other hand, if the instructor uses the kind of judgment he hopes to develop in his disciples, the criticism must fall for want of experimental or logical support unless the experience and belief of the writer is entirely vain.

One method of arranging the collective work is to urge a class to divide itself into congenial groups of five or six men each and to have regular times and places of meeting. From two to four periods of an hour each per week are probably sufficient for the purpose; with the room of a student or some other attractive place for a meeting point. No objection can be raised to the addition now and then of a cup of tea and a bite of crackers and cheese if the primary object of the gathering is not thereby obscured.

Does any instructor or class officer who has endeavored to vary, by such means as I have proposed, the pedantic regularity of the scheduled college exercises care to deny the very great usefulness of such methods? If so, I doubt not that he has failed to make his trial with a proper spirit and understanding. The English universities have for some time made use of

this informal method of education with, so far as I have been able to learn, highly satisfactory results.

Having listened to the foregoing arguments, the gentleman with pessimistic inclinations will dismiss the whole subject with a wave of the hand and the remark: "The scheme sounds well on paper but it will not work in practice." He will aver that the youths when assembled will eschew thermo-dynamics, alternating currents, bridges, and other weighty matters of discourse and will promptly fall to the pitching of pennies, the singing of college songs, the raising of an uproarious good time as is the wont of the callow college youth; further, that they will enter the class-room hollow-eyed and dull of mind as a result of the dissipations of the night preceding. His verdict is certainly scathing, but it is in exact opposition to the writer's personal experience of the past two years. The junior and senior sections of the electrical engineering course at the Pennsylvania State College have done much collective study. After their informal meetings they have usually entered the class-room full of enthusiasm and self reliance as an effect of the inspiriting mental brush they have recently had together.

However you may view the suggestion contained in this paper, we must agree in wishing our students to develop into more than mere machines, or mechanics, or unabridged encyclopedias of information. We earnestly desire that they may become self-reliant, right thinking men; that they may be imbued with aspirations that will carry them high above those of the common herd whose goal is personal gain and bodily comfort; that they each may say with Schiller that "knowl-

edge is a goddess both heav'nly and high" and not, as might readily be, "only an excellent cow yielding the butter he wants." If the method suggested may add one jot or tittle, however small, to the accomplishment of this end it must be conceded to be well worthy of your consideration.

DISCUSSION.

PROFESSOR H. P. TALBOT.—Would like to ask of the others: Is it possible to bring together the indifferent students, as well as the bright students? Will they voluntarily come together? His own experience was that while the system might easily prevail among the better men, many men would not agree to it without persuasion.

PROFESSOR J. P. JACKSON.—Would say that the lazy man would not study any way. Not any more, together with others, than alone. But in one month of this system, many get a little touch of the real enthusiasm of the student.

PROFESSOR H. P. TALBOT.—But a man may try and yet find it difficult to get hold of a subject. It seemed to him that the thing which all must want in this connection is a method of training students to study, of making it, in the first place, profitable study. But it seemed to him that much of the trouble with students lies in the fact that they come from secondary schools without a disposition to think for themselves. It then becomes a question of doing the best you can with all classes in a short space of time, and even in college work there is grave danger that with the large number of subjects and the small amount of time for each, the pupil may go through the various courses, without having had an opportunity to think for himself.

There is a lack, among many men of average ability, of a real enthusiasm for the work they are doing. It should be suggested to them that they do not depend so entirely on text-books, and have more dependence upon themselves. He had tried it many times, but in such a way that they did not feel that he meant any one personally, and when he came to observe the result, it seemed to him that they were not doing as well as they might. They did what was required, but not much more. The general spirit of haste accounts for the trouble we have had in persuading students to study well.

Professor J. P. Jackson.—I have felt that one of the most efficient aids I have had in teaching mechanics has been the work of the students together in one way and another. I hear them talking among themselves, taking up different points which puzzled them. Does this reach the indifferent students? I know that it does. I believe that some of their fellow students are better teachers for some of them than are the professors. They get a view of the subject which may not be exhibited in the class-room. I have found that men who failed to grasp the subject, really men of ability, have failed, it seemed to me, because they kept out of this discussion. They tried to do it all themselves.

In such a subject as mechanics, the work of the students among themselves is a very effective aid.

Professor Emory.—Along the same line we have all had experiences in what, we feel, has been a help to the student who is a little slow in picking up the subject. Sometimes a man appears before you who is indifferent, who has no interest in the work apparently, yet who

develops into a first-class student. I have had such in my department. And I have employed these same ideas, but in a little different way. I make the students bring note-books. The bright student sees that they may help very much and uses them. At examination time he knows the subject and comes out ahead—ahead in what he has been doing and ahead of the others.

PROFESSOR C. F. ALLEN.—I think there can be no doubt of the fact that success has sometimes been acquired by the method Mr. Jackson suggests. I do not feel sure that the results would be the same in all subjects. I do not feel sure that it can be carried out in all places. In a large city, where very many of the students have homes within easy reach of the college, it would be difficult to get the students together, however much it might be desired. Among the hills of Pennsylvania, where most of the students live at the college, the conditions would be exceptionally favorable for that class of work. I should think the subject of mechanics was especially favorable for this system. I am pleased to believe that in some subjects it would be desirable. I remember in my student life, if a good stiff lesson in German was on, it was the custom for six or eight students to get together around one desk for the first reading of the lesson. I usually had the pleasure of reading. It was a special success, as far as I was concerned. I am not sure that the rest of the students were benefited equally. I am forced to think of their dependence on my knowledge; and yet it is fairly possible that the first reading in this way was the best preparation they could make for recitation in class.

I remember, in still earlier student life, when public recitations were an occasional occurrence, that I entirely failed to get the idea of doing more than repeat words, until I was sent into a room for instruction from an older student who was fine in that work. I learned for the first time that I was to talk to my audience, and public declamation was to me a new and living thing from that day forward.

In my own work, where there are a great many problems to be done out of class, I insist on the students doing their own work and not working together. And the student who works independently learns to take the lead himself, instead of asking his industrious roommate how to tackle the problem. In that particular work, I insist that the work shall be strictly independent and individual.

The point I wish to make is that Prof. Jackson is right and the others are right who use this method in the right place and at the right time. It seems to me that however much we may desire to use it, there are many times when the circumstances do not allow it, and then we are handicapped in not being able to use it. It certainly should not be used altogether in mathematical subjects, but the student should be put upon his own resources frequently and compelled to work absolutely alone.

It is desirable that some problem work should be done in the class room, where the students will be put positively upon their own resources, where they cannot receive aid from others.

PROFESSOR DIEMER.—It seems to me that in problems in certain subjects, such as valve gears, graphical

statics, etc., the working out of the problem jointly by students, saves a great deal of unnecessary work. On the other hand, I have been with students working up notes of engineering laboratory work, and have found that out of a class of eight or ten, there would always be two or three who would be taking the lead. On the other hand, there are some who could not work out simple slide rule operations if they took four times as much time as the leaders. These slow people, instead of making progress are becoming more inefficient as a result of their working jointly with the rapid ones. It seems to me that joint work, in a class like this, is to the slow student's detriment.

PROFESSOR RAYMOND.—As far as my experience goes, good men do the work for themselves. A weak man depends entirely on others. There are different classes of students. It is natural for some students to study. They never stop with the assignment. They are in school for a purpose. They go as far ahead as they can, and spend plenty of time in addition to that necessary to perform simply the assignment. Another class is not made up of students; that is, not natural students. They are sent to school and they go to school. They are satisfied when they have done the particular lesson assigned to them. It is the same in after life. It is the same in shop and in dry goods store. They are content to do the assignment; others do all they can.

As to how a man should learn, I cannot say. One learns by seeing, another by hearing; one learns by questioning, another depends on others teaching him; and sometimes the latter are the more successful; they use others' brains.

RATING OF LABORATORY AND CLASS-ROOM WORK IN SCHEDULES OF COURSES.

BY F. C. CALDWELL,

Professor of Electrical Engineering, Ohio State University.

Most college catalogues undertake to give, either in their schedules of courses or in their lists of subjects taught, or in both, some information with regard to the amount of work that is expected from the student in the different subjects studied. This is not as easy to do as might at first sight appear, for it is to be borne in mind that the important points are the amount of ground covered in the subjects and the way in which it is covered, and not the amount of time occupied in the work. I do not know, however, that it has ever been attempted in catalogue making, to use this method in stating the amount of work done, and it is very doubtful whether it would be practicable without an inordinate expenditure of printer's ink. There has come down to us from former times a kind of symbolical method of measuring the work accomplished, which states it in terms of some arbitrary unit, usually one recitation a week for one term or semester. At a time when there was neither laboratory work nor electives such a method as this was probably very satisfactory. It served to tell the students how many times they were to go to class, and as the subjects taught were very similar in their general character it may have given quite an accurate relative measure of how much work was being done in the different studies. When laboratory work

was first tolerated, as what was generally considered an unimportant adjunct to class-room courses, it was natural that it should be estimated in terms of class-room hours. Since that time, however, and especially within the past few years, conditions have very greatly changed and this method of reckoning time has not proven elastic enough satisfactorily to keep up with them.

With a view to ascertaining what the present practice in this matter might be, an examination was made of the catalogues of twenty-seven of the principal universities and technical colleges of the country. Two of these were so indefinite that no satisfactory information could be obtained; of the remaining twenty-five, seven stated the number of recitation hours and the number of actual laboratory hours required and made no attempt to establish an equivalence between them. This method is, of course, practical and rational for required work but fails when the question of electing between class-room courses and laboratory courses is presented, or when it is desired to compare the amount of work in different courses. Of the remaining eighteen colleges, nine made it more or less evident in the catalogue that three hours of laboratory, shop or drawing was required as an equivalent of one hour of class-room work, five others made this equivalent two hours instead of three. One makes it from two to two and one half, and one from two to three according to the amount of outside preparation required. Again one makes it three hours for shop and drawing, but two and one half for laboratory, while another requires three hours for shop and laboratory, but two hours for drawing. Of these

institutions, eight state that two hours of preparation are expected upon each hour of recitation, thus in so far as this condition is maintained, making laboratory work the exact equivalent of class work. Most of those colleges where two hours of laboratory is taken as the equivalent of an hour of class-room work, also imply an equivalence between the class and laboratory by limiting the number of hours which the students may take, without any stipulation as to whether the work is laboratory or class. It would seem, however, that, as in most of these cases the number of units ranges from fifteen to twenty, the resulting thirty to forty hours as the total work per week, would be absurdly small for the average man.

From this investigation it appears that a considerable number of the institutions studied agree in considering an average of three hours as about the total time corresponding to one hour of recitation, and this amount is probably approximately right as an average, but the considerable range in the assumptions made would seem to show that the general method of reckoning the work is somewhat at fault. That this is not an imaginary difficulty is witnessed by the fact that at least two colleges which purport to consider three hours of actual work as the equivalent of each class hour make definite exceptions in the case of certain studies where a larger amount of time is spent in the class-room than would be warranted by the credit allowed for the subject. Another weak point in this method is indicated by the use of fractional units in the schedules of several colleges.

The assumption that every class-room course should

take the same amount of preparation per hour of time spent in the class-room, seems of very questionable soundness. Certainly with more advanced classes in mathematical subjects, two hours of preparation for an hour in class does not seem always sufficient, whereas, on the other hand, there are occasional lecture courses upon subjects in which there is not much available reference matter, where a student could hardly spend profitably two hours of preparation for each lecture.

There are, however, two institutions which seem to have gone a step further in rationalizing this method. These are the Worcester Polytechnic Institute and the Massachusetts Institute of Technology. In both these cases the assumption is made as to the total number of hours that the average student could be expected profitably to employ in college work during the week. This assumption would, of course, bring out a great difference of opinion, but it would seem that it should be at least no more difficult to determine than would be the number of classes that an average man could prepare for. Having thus assumed the number of available hours, this time is divided by the faculty between the different courses that are to be studied and then the instructor having charge of each course is at liberty to divide the allotted hours between attendance upon class or laboratory and preparation in any proportion that may seem most desirable. Thus, a course in shop work where all the work needs to be done in attendance, would be scheduled for the whole time allotted. A laboratory course which might require half as much time in preparation or working up results as needed to be spent in the laboratory would be scheduled for at-

tendance during two thirds of the allotted time. Again, a lecture course requiring little outside work would be scheduled for, say, one half of the allotted time, allowing one hour of preparation on each lecture; while an advanced mathematical course might, if desirable, require attendance for only one fourth or one fifth of the total time. This system seems to have been carried out successfully in the two institutions named. In the case of the catalogue of the Worcester Polytechnic Institute, it is perfectly simple for any one, whether connected with the institution or not, by examining the schedule for the courses which aggregate about fifty-three hours per week, to ascertain just what part of the sudent's time is to be given to each of the subjects studied. It would seem also that this would make much more unlikely the exorbitant demands upon the student which are often found in institutions where the unit system is in vogue. It is not believed that many college instructors intend to call upon students for more than their share of time, but the unit-hour system is so indefinite that they often do not know unless their attention is called to the matter, that they are doing so, and the student is often in some doubt as to how much of his time he should be expected to give to the subject in question. The system at the Massachusetts Institute of Technology seems to be even more complete, though it is not given in their catalogue, where actual hours of attendance only are stated. The "departmental record" cards of the students, however, state explicitly how many hours of preparation as well as of attendance are to be expected for each study, as shown in the accompanying sample. This seems to be about the best that

Massachusetts Institute of Technology. Course I. Departmental Record.

First Term.

First Year.		Record.	Second Year.		Record.	Third Year.		Record.	Fourth Year.		Record.
Algebra 20	30–60		Astronomy 443	15–15		Applied mechanics 70	60–120		Astronomy 468 (1)	15–30	
Chemistry 290	105–90		Descriptive geometry 110	75–15		*French II. 191*	45–90		Bridge design 478	90– 0	
English 160	30–30		Differential calculus 33	45–90		Geol. Struct. and Lithol. 670	30–15		Foundations 499	15–30	
Freehand drawing 115	15– 0		English literature 165	15– 5		*German II. 201*	45–90		Hydraulic measure 473 (1)	20–10	
French II. 191	45–90		European history 221	30–10		Physical laboratory 373	15–10		Hydraulics 470	45–90	
German II. 201	45–90		*French I. 190*	45–90		Physics 370	15–20		Industrial electricity 410	15–15	
Mechanical drawing 100	90–[illegible]0		Geology 662	30–15		Political economy 245	30–30		Metallurgy of Iron 587	15–15	
Military science 900 { A	45– 0		*German I. 200*	45–90		Railroad engineering 453	30–60		Railroad design 493 (2)	45– 0	
Military science 900 { B	30–15		Physics 360 {45, 30}	60		Railroad drawing 452	60– 0		Railroad eng. 465 (2)	30–30	
Trigonometry 22	30–60		Survey. & C. E. Draw. 440	90– 0		Stereotomy 455	60–0		Railroad manage. 466 (2)	30–30	
			Summer reading			Surveying 450	30–0		Railroad signals 423 (2)	(see 465)	
						Summer reading			San. & h. eng. 472 (1)	45–45	
									Steam engineering 541	30–60	
									Structures 474	45–90	
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I. Corrected to January, 1903											

Second Term.

First Year.		Record.	Second Year.		Record.	Third Year.		Record.	Fourth Year.		Record.
Analytic geometry 27	60–120		Civil eng. drawing	[see 440]		Applied geology 682	30–15		Bridge design 478	90– 0	
Chemistry 291	90–75		English literature 165	30–30		Applied mechanics 70	50–100		Building construct. 649 (2)	15–15	
Desc. geometry 102	90– 0		*French I. 190*	45–90		Business law 275	15– 5		Engineering laborat'y 480	16– 5	
English 160	15–15		Geol'y, struct. & lithol, 670,	30–15		*French II. 191*	45–90		Geodesy 497 (1)	15–15	
Freehand drawing 116	30– 0		*German I. 200*	45–90		*German II. 201*	45–90		Hydraulic eng. 491 (1)	45–90	
French II. 191	45–90		Integral calculus 38	45–90		Highway engineering 454	15–15		R. R. design 493 (2)	45– 0	
German II. 201	45–90		Mechanism 520	30–60		Physical laboratory 373	30–30		R. R. engineering 465 (2)	45–90	
Military science 900	A 45– 0 B 30–15		Physics 360	45 30 } 60		Pol. econ. & ind. hist. 245	15–25		San. & hyd. design 494 (1)	30– 0	
						R. R. draw. & fieldwork 452	75– 0		San. sc. & pub. health 750 (1)	15– 0	
U. S. History 220	30–30		Surveying 440	75–15		R. R. engineering 453	30–30		Steam engineering 541	30–60	
			Telegraphical drawing 442	30– 0		Structures 460	25–50		Structures 474	75–150	
						Surveying 450	30– 0				
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I. Corrected to May, 1903.											

Numbers immediately following subjects refer to Subject Schedule in catalogue of 1902–1903.

can be done along this line, though this information might perhaps be included in the catalogue.

In stating schedules it appears at first sight natural to base them upon the ability of the average man; but there is much to be said in favor of taking instead, the poorest man as a starting point. It would seem easier to agree upon the largest number of hours per day that any student, even the poorest, should work, than to determine this for a rather indefinite average man. What this amount should be would depend somewhat upon whether the student had any considerable quantity of shop or other work which would be in some degree a mental relaxation. It probably should not be the same in every term. Perhaps ten hours a day or sixty per week would be about right. It certainly would not be more than some students work now. With such a schedule a complaint of overwork from one or two students would mean that they were carrying more work than they were equal to, while a complaint from a considerable part of the class would indicate clearly that too much work was being required. There would then be no necessity for considering the average man in the class.

It is of course important that the student should not be allowed to get the idea that putting in time is what is expected of him. Thus, for the successful carrying out of most laboratory work I believe that it is essential to lay out a reasonable amount of work which must be accomplished in order to obtain the passing grade.

In conclusion, I would urge a more general consideration of this matter in the interest of greater clearness and uniformity in catalogue statements of courses,

greater uniformity in the amount of work required from different students, and in general, more satisfactory results in working under the schedule used.

Discussion.

Professor Woodward.—In engineering courses we want students to do the work. It is not important, when the course is laid down, whether we balance the number of hours on it. The work must be done. But in elective courses of study it is important that there be no "snap" classes.

Professor J. P. Jackson.—Professors unintentionally assign excessive lessons. Thus a fairly bright man in a class in chemistry attempted to prepare the lesson assigned and gave evidence of having expended seven hours in the work. My observation and experience in the matter leads me to believe that the best way is to assign three hours to the period and to permit the professor to utilize this time in any way he thinks best; for instance, one hour in recitation, with two hours in preparation, three hours in lecturing, three hours in laboratory work, or three hours in shop work.

Professor Duncan.—I have found that the work required during junior year is very irregular. In sophomore year, the student has mechanics and chemistry, descriptive geometry, drawing and a large amount of shop work, and he will usually pick out one subject in which to excel. The result is that things do not go smoothly. This is one point to call attention to in planning courses.

Professor Jacoby.—May I express the hope that the author of this paper will include several copies of the

courses which are made out for the convenience of the student in the institutions named in the paper? It would tend to give a fair idea of the details of their work. Preparation is improperly done by a good many students. My idea is that the amount of work a student will do depends not upon the student nor upon the faculty's action nor upon the catalogue, but upon the professor. He will either execute it or get along with nothing. It depends entirely upon the professor.

PROFESSOR WALDO.—Mr. President, I would like to make just one remark upon Professor Caldwell's paper, and it is to this effect: if we expect to keep peace in our faculties, we must have the time properly distributed for the different subjects.

TWO KINDS OF SPECIALIZATION AND FUNDAMENTAL PRINCIPLES IN PLACE AND OUT OF PLACE.

BY ARTHUR L. WILLISTON,

Director of the Department of Science and Technology, Pratt Institute, Brooklyn, N. Y.

I am not sure but I owe the Society an apology for presenting a subject on which there has been so much discussion, but it seemed to me and it seemed to a number of others to whom I spoke that the subject of which this paper treats has been left in a very unsatisfactory state, and that is the reason for this paper appearing at this time.

At the last two meetings of this Society, under a number of different headings, there has been considerable discussion and many expressions of opinion regarding the advantage and disadvantage of specialization and differentiation in the course of study leading to the engineering degree. At the Buffalo meeting, two papers were presented, warning us against the dangers of specialization, and these were quite generally discussed; and at Pittsburg a year ago, by vote of the Council, the subject was continued, several members having been asked in advance to present written remarks to open the discussion.

The casual reader of our transactions, in glancing through the printed record of these proceedings, would naturally draw the inference that this Society, or at least a considerable portion of its members, was op-

posed to specialization, and that it advocated a single general course of study for all engineering students during a large part of the four years, regardless of how various are their interests and abilities and how different the callings which they are likely to enter after graduation. If it is true that this is the opinion of this Society, it seems to me most unfortunate.

In all the development and almost marvellous industrial and social changes that have been wrought during the last half century in the United States by the application of science and the scientific method to all our work and thought, no one thing stands out more clearly, it seems to me, than the almost universal tendency toward more complicated organizations. We see this in every department of life, and with it we see the necessity for increased specialization. Even within the last decade the number of well-defined vocations has increased greatly, and in most of them efficiency and success are found to depend upon specially trained ability for the peculiar needs of the particular calling. In the face of these facts, it seems to me strange indeed if this Society should wish to put itself on record as expressing the opinion that in every field of human activity, except education, specialization is the natural order of progress, but that in education, which is supposed to prepare for life, specialization is unwise, and should be avoided.

I am sure that it would be a surprise to many to see unchallenged upon the records of our meetings the statement that men may be "trained but not educated," simply because they have not received instruction in certain subjects that we have learned to regard as

academic, simply because we have learned to teach them well. This looks strangely like the arguments of the conservative advocates of the old classical training of twenty years ago. The statement, repeated a number of times in our discussions, that one general training through a large part of the engineering course is best for all, is suggestive of the same. At a time when the former advocates of the classical training have almost completely abandoned their old ground, and have at last recognized that a man may be educated through study in any branch of knowledge; when the secondary schools throughout almost every part of the United States are being reorganized in conformity with this idea, as our President has so well described to us in his opening address; when the president of Harvard University chooses for the subject of his presidential address to the National Educational Convention, "The New Definition of the Cultivated Man," is this Society, founded for the promotion of engineering education, going to use its influence to stand in the way of progress by saying that it is satisfied with things as they are and with what we have already accomplished; that all we need do is to continue to base our courses on the old "fundamental principles" worked out years ago, and if anyone complains because he thinks he is not getting all that he thinks he ought to have, tell him that if he wants special training for his chosen calling that he must take a graduate course to get it? I do not believe that this Society means to stand for any such idea, yet one might easily infer it from the discussions that I have referred to.

Seriously, I think that much of this confusion has

arisen because, at the outset, we have not carefully defined our terms, for I think we all will be willing to draw the general conclusion that, as the practical work of life becomes more highly specialized, the courses of instruction in our schools and colleges must recognize the fact and shape themselves in accordance, if they are to satisfy the real needs of the people. If this conclusion is not true, then the basis of the theory on which our engineering schools are founded, that principles can be most effectively taught in connection with their practical application to problems of live interest, is false, and we would better go back to the old system of education.

As soon, however, as our discussion is expressed in other than general terms, and we attempt to make application of it in our courses, the real difference of opinion commences, because some of us, when we look about, see courses that are highly specialized that we wish to commend, and others, when they look in other directions, see instruction calling itself specialized that they do not approve and cannot endorse. In other works, there are two kinds of specialization; good and wise specialization, and specialization that is neither good nor wise. In a few words I will try and illustrate this.

Some institutions, in order to meet the demand for more practical courses in some special lines, have introduced into their curriculum certain "information courses," which deal with a large number of practical details and give unassimilated facts in place of older courses that had been more carefully worked out. In such cases, because the underlying laws and lasting truths have not been fully traced out, it has not been

possible so to present the work as to require of the students the continual exercise of thought and judgment. As a natural result, such specialization has been inefficient educationally and has been unfortunate from every point of view. In some other institutions, classes that were already small have been subdivided in order to meet the demand on the part of the students for training in an increasing number of specialties. New teachers have accordingly been employed to work upon and develop new branches of applied science. This has increased the cost of instruction per student and has been a drain on the resources of the institution, which has perhaps prevented the payment of adequate salaries or the expenditure of sufficient money for equipment needed in other directions. The result of such specialization has been equally unfortunate also in another way. In still other institutions, new courses of study leading to new degrees have been established by grouping together a number of existing courses that were intended perhaps for widely different purposes, and then calling this conglomerate by a new name. Thus somewhere a course in chemical engineering may have been established by taking some mathematics, a short course in shop work, intended for electrical engineers, some mechanism for mechanical engineers, a little drawing and descriptive geometry—planned for no one in particular—a few lectures in electricity which are given to civil engineers, a course in metallurgy, designed for another group of students, and then the balance of the time is filled in with some of the regular courses in chemistry. The instruction in these individual subjects may be admirable, but it is needless to

say that the result is not a course in chemical engineering for it is not a course at all. It is simply a grouping together of fragments of courses. This kind of specialization is, I believe, even worse than the other two that I have just described, because it is more general and because there is less chance that the evils arising from it will be soon outgrown. A course in chemical engineering is here chosen for illustration without the slightest intention of casting any reflection on well-planned courses in this important branch of engineering in which the writer most heartily believes.

There are probably other types of unwise specialization, but I have said enough, I believe, to illustrate my point and to show that there is justification for all that has been said in our previous discussions against the bad kinds of specialization.

There are, however, still other institutions with perhaps sufficient funds at their command, or with an enrollment large enough so that subdivisions of classes does not appreciably increase the cost of instruction, that have, year by year, tried to keep pace with progress in the field of engineering by continually adding new subjects to their curriculums and new courses of study leading to new degrees, taking care always to have the latter unified, and also always being careful to have every new subject thoroughly worked out before it is presented to the students, so as to have everything based upon sound scientific and educational principles. This is the good kind of specialization, and I, for one, want to place myself on record as believing in it.

Whenever a sufficiently large group of young people can be found whose interest in any subject is suffi-

ciently earnest and profound to make them decide to choose their life work in that field, then I believe that specialization cannot well begin too early or be carried too far, always provided that the funds are sufficient and that competent men can be found to do the teaching. All that it is desirable for these students to know to make their education broad and sound I would teach to them in its relation to the subject of their central interest; and all instruction could be coördinated to make it a single unit, instead of being a number of fragments. In the accomplishment of this, I would teach different subjects differently to different groups of students; mathematics to civil engineers one way, to mechanical engineers another, to chemists another and to architects still another, each related to this specialty. I would teach general chemistry differently to electrical engineers and to chemists, and physics and mechanical drawing differently to mechanical and to electrical engineers. The beginning of the secondary school course is not, I think, too early for this kind of specialization, whenever the path in life has been sufficiently predetermined, and when the groups of individuals needing the same training are large enough to make such a course economically feasible. For surely it would be well to teach arithmetic and grammar and history differently to a group of boys who were going to become plumbers from those that were preparing for college. If perchance a young man, here and there, finds that he has chosen the wrong course, no harm has been done, for in learning how to master one field of knowledge, and seeing it in relation to all others, he has learned the process by which all problems are solved. He has

most wisely spent his efforts in the field in which, for the time being, he had the greatest enthusiasm. Professor Allen spoke well a year ago when he said that a young man thoroughly trained in any one field of applied science can be trusted to give a good account of himself in any other, and also that in almost any engineering course there is danger of lack of depth rather than lack of breadth.

I fully realize the practical difficulties in the way of differentiating courses to the extent that I have suggested, but it seems to me that the idea that I have indicated is in the right direction, and is the one that we should try to follow as fast as these difficulties can be overcome; and, one by one, I think we may hope to see these difficulties disappear if all work for that end.

And now just a word regarding "fundamental principles," for some may think that I have already spoken disrespectfully of them. Nobody has a higher regard than I for fundamental principles—in their place. But like many other good things, I believe they have their time, and place and season. The best definition that I have been able to formulate for this term that we all use so often is, "a fundamental principle is the scientific explanation—usually mathematical—of some practical problem."

I have known courses—courses in sophomore physics and junior mechanics for example—that were made up almost entirely of these "fundamental principles," that were explanations of problems that are real perhaps to the instructor but that are explanations of absolutely nothing to the student, because the practical problems to which they are the natural solutions have not yet

come within the range of their experience, and yet their teachers will justify this instruction on the ground that it is all founded on fundamental principles. They might as logically fill their courses with so many answers to conundrums, trusting to luck that the student would at some time later in life meet these conundrums, and remembering the answers would, in some miraculous way, recognize the riddle to which each particular answer refers. The point that I wish to make here is that principles, so long as they are introduced to solve some live engineering problem, the details of which the student is familiar with, are absolutely essential to sound instruction, but that introduced as the solution of problems that are not worth solving for their own sake, they are out of place in an engineering course. The time would better be spent in other ways.

There are now many subjects in our courses that relate to engineering problems of the past that have been long since solved, and so far as general interest is concerned are now absolutely dead, yet they are still retained because we have become so attached to the particular fundamental principles that underlie them, that we think that we could not get along without them, forgetting that the principles underlying the live problems, which are absorbing the interest of engineers today, have as much to commend them. The scientific and economic principles of modern foundry practice, when rightly taught, are worth more than valve motions. The design of automatic machinery is worth more than old-fashioned mechanism. Modern machine tool design is worth more than shades and shadows and perspective. The design of special tools for cheap

production is worth more than descriptive geometry. Modern methods of machine construction are worth more than the old-fashioned methods in use in almost all the school shops of to-day.

As a general rule, I believe that whenever it is necessary for us to bring forward the argument of "fundamental principles" as a reason for retaining a subject in an engineering course, that it is time to ask the question seriously, is it not wise for it to go, and give way to some more modern problem? We will find the latter, as a rule, to require quite as much thought and judgment as the old-fashioned ones—although perhaps not always quite so much mathematics. If this is the case, there is small harm done, because there is at present danger with most of our courses that the student will imagine that all engineering problems can be solved by mathematical methods, and that whatever cannot be solved in this way may be neglected.

Discussion.

Professor J. P. Jackson.—Mr. Williston is original—very original beyond a question—and he arraigns the Society's transactions quite severely. I am also inclined to believe that we have gone more or less beyond moderation in the subject of speculation and non-speculation. I am not an agriculturist, but my impression is that a farmer—a good farmer—plows his land, harrows it, and rolls it, and the more thoroughly he cultivates his fields, more faithful the harvest. Likewise there are, the old pedagogues used to say, three kinds of mental cultivation of the brain. One is a general cultivation such as is given by language, history,

and the various other studies of that nature; the second is mathematical training; and the third is the study of physics, which includes chemistry, mechanics, and the various lines of engineering. The men of classically trained minds, who are passing rapidly—possibly too rapidly for our best welfare—have said that we must also have more or less of the classics in order that a man's mind may receive suitable cultivation. I believe fully with Professor Williston that if a man can specialize and yet obtain a due amount of these three general lines, so that when he goes out of college, he has a broad, well cultivated mind, he should certainly specialize. But it is well to remember that a college course is for mental training first and for the acquiring of knowledge afterward.

PROFESSOR GALBRAITH.—I have listened with great interest to the author's thoughtful paper, and it seems to me that the difference between his views, and those so often expressed in this society in favor of training the student in the principles of the engineering sciences, is more apparent than real. There can be little doubt that the principles of chemistry will be better taught to engineering students by a professor who is familiar with the requirements of their future profession, than by one who is not: if in the same university chemistry is taught to future teachers, engineers, and medical men by the same teacher and in the same classes, it is probably due to want of funds, to necessity, rather than to a belief in this method being the best. However, after the student has obtained a grasp of a principle by means of illustrations drawn from the profession in which he is interested, the author

would not object, I imagine, to the teacher reinforcing his teaching by drawing upon any facts at all, which may be within the knowledge of the student.

While agreeing with the author in the above views, I must dissent from his statements respecting automatic machinery and mechanism, machine tool design and descriptive geometry, etc. I probably have failed to understand him. It appears to me that such comparisons ought not to be made, the subjects compared not being of the same kind nor having the same purpose. There are certain branches of science which are of interest to all classes of engineers and which should be made obligatory in engineering courses. These branches will always be better taught by the direct method than by attempting to introduce them as they may be incidentally required in the prosecution of a highly specialized study, such as for instance the design of machine tools.

President Woodward.—There is one saving remark in what Professor Williston said. In telling how he would teach subjects differently to different sets of students, he said: "I would teach thus and thus if I knew the student was to become a plumber." Well, that is exactly what we don't know, any of us, and therefore we must not assume that we know.

One other thing: he would begin specialization with the secondary school. I claimed yesterday that the secondary school was the field in which the student should learn how and when to specialize but that specialization should come at the end of the secondary school and not at the beginning of it. In my judgment the secondary student is utterly unqualified to specialize; he has his

head filled with whims; he has ambitions put into it by other people; he has suggestions from his environment, but he has not any definite knowledge of himself nor of the world at that age, and therefore the teacher ought not to suppose that the boy's whims and fancies and tastes, in the secondary school, are of any great account. They are not to be discouraged; they are not to be contemned; they are to be politely and quietly ignored.

PROFESSOR WILLISTON.—In answer to the remark made by one of the previous speakers that the difficulty was largely one of funds, I would like to make a suggestion that I did not include in my paper. I believe if the colleges that do not have all the funds they would like for specialization in many directions, would be satisfied with doing some few things very well, and would not try to do all the things that all other institutions were doing, it would be possible for them to make a reputation in the narrower fields which would be far superior to any reputation that they can make where they try to copy other institutions that have larger means and better facilities.

In different parts of this country the needs are different, and it is right and proper that engineering colleges in certain places should select certain courses and say "we will make those courses the best courses in the United States of this particular thing." But they ought not to try to do so many things as many of them are trying to do now.

In answer to the remark regarding general education: I stated carefully in my paper that in this highly specialized course I would teach everything that I thought it wise for that particular individual to know, all of the

broadening subjects and all subjects from a broad point of view, but all related to the subject of his central interest.

In answer to the remarks of our president, I would say that I disagree with him on the point that we do not know, even at the beginning—I will say at the end—of a grammar-school course, what a very large proportion of boys are going to do. The large proportion of them are forced to go to work at once and do choose their life work then and there and stick to it because they can't get out of it. As to those boys who do know, I would specialize in their case. And I would say, and I think I know whereof I speak, for my experience with this class of individuals has been quite intimate, that there is a much larger proportion of those boys fifteen years of age who do know what their life's work is going to be than those who do not know. I agree heartily with our president in his statement that the period of secondary education is the period for him to find himself out and find wherein to specialize, for every student who is going to have a later opportunity to specialize, for every young man to whom there is a possibility of a college education, that statement is unquestionably wise; and the way in which I would specialize for those boys who have a possibility for higher education, would be by giving them the opportunity to browse in every field and find out wherein their special ability lies.

ASTRONOMY FOR ENGINEERS.

BY CHARLES S. HOWE,

President of Case School of Applied Science, Cleveland, Ohio.

Astronomy is generally regarded as a culture subject. It is taught in schools and colleges to give the student general information, mental discipline and a broader conception of the universe. Upon these grounds it has no place in a technical college which is a professional school and not a place for general culture. But it is apparent to those who have given the matter any attention that astronomy, in some of its phases, is a practical subject, and that a knowledge of it is absolutely essential in certain professions. The position of a ship at sea is determined entirely by astronomical means and it depends upon the accurate knowledge of the places of the stars in the sky which must be obtained in the astronomical observatory. For the navigator, then, astronomy is a necessity. Accurate time must be determined by astronomical means from the stars, the positions of which are already known. The boundaries between states and countries can be determined only by astronomical methods. The boundaries of large tracts of land should also be fixed by the same methods, for they can then be retraced at any future time regardless of the destruction and loss of monuments. Every important survey should have the azimuth of one line determined by astronomical means, for then if a single monument is left at any future time or if the latitude and longitude of any single monument are accurately

known, the whole survey can be retraced. Without the azimuth of this one side it would be impossible to retrace the tract unless two consecutive monuments remained. But these latter problems are engineering problems that are not for the astronomer but for the civil engineer. It is very evident that he cannot take hold of questions of this nature unless he has received instruction in practical astronomy. While the technical college cannot give a broad course of training it should turn out educated engineers, and I cannot think that a civil engineer is broadly and thoroughly educated unless he has some knowledge of this subject. These problems which I have mentioned are taken up by civil engineers and this subject needs to be given to them only. Much time and money would be saved and much useless litigation avoided if engineers had a knowledge of astronomy, and in all important surveys would obtain the azimuth of one line. The work of obtaining azimuth is exceedingly simple, but it is surprising to note how few engineers have any knowledge whatever of the methods of determining it. A good watch and an engineer's transit are the only instruments needed.

It would be interesting to note how many of the technical colleges teach practical astronomy and the number of hours which they give to it. Not having time since I began this article to write to the different technical colleges, in order to find out just what they are doing, I have made a rather hurried examination of their catalogues and from them have constructed the following table. I fear that some of my conclusions may be erroneous because it is quite difficult in a short time to trace out the details of a college course from a catalogue.

Practical Astronomy in Technical Colleges.

Name of Institution.	No. Weeks.	Hours per Week.	Total.
Armour Institute			none
Brown University (prac. astr. and geod.)	36	3	108
California, University of	18	9	162
Case School of Applied Science	8	30	240
Columbia University (estimated)	3	48	144
Cornell University	12	6	72
Dartmouth College	no amount stated		
Illinois, University of	18	2	36
Kansas, University of	18	1	18
Lafayette College	12	2	24
Lawrence Scientific School	no amount stated		
Lehigh University	18	2	36
Leland Stanford University			none
Maine, University of	9	5	45
Massachusetts Institute of Technology	18	2	36
Michigan, University of	18	3	54
Minnesota, University of			72
Missouri, University of	18	6	108
Nebraska, University of		none required	
Ohio State University	12	4	48
Pennsylvania State College (lectures only)	18	2	36
Pennsylvania, Univer. of (p. a. and geod.)	18	4	72
Purdue, University of	18	2	36
Rensselaer Polytechnic Institute	Given, time not stated		
Rose Polytechnic Institute			none
Rutgers College			none
Sheffield Scientific School (P. A. L. S.)	18	3	54
Syracuse University	36	2	72
Tufts College			none
Vanderbilt University	18	3	54
Vermont, University of			none
Virginia Polytechnic Institute			none
Virginia, University of	no definite statement of course		
Washington University	18	3	54

Western University of Pennsylvania, geodesy and astronomy, time not given			
Wisconsin, University of	18	4	72
Worcester Polytechnic Institute	11	15	165
Union College (prac. astr. and geodesy)	12	4	48

Of these 38 technical colleges, 9 do not offer any course in this subject, 4 make a very indefinite statement and 25 give courses varying from 24 hours to 240 hours. The average time is 75 hours. If the student spends an equal amount of time in preparation, he will give altogether 150 hours. I do not see how in any less time than this he can obtain any satisfactory knowledge of this subject.

It takes considerable time for a student to comprehend the fundamental definitions of astronomy, and to get a clear conception of what he is expected to do. Then he must learn to make accurate observations and reduce them. It is not a very great task for the student to learn from the book the definitions of right ascension, declination, hour angle, sidereal time, mean time, etc., but when he tries to apply these definitions to the sky; to go out of doors at night and point out the hour circle of a star, or where the vernal equinox ought to be at that particular time; or in computing to show why certain operations are performed in changing sidereal time to solar time and vice versa, I have found that book definitions do him very little good. There must be practice out of doors and practice for more than one night before these fundamental definitions become real, and before he can see the constellations clinging to the inside of a celestial sphere upon whose surface the triangles of spherical geometry can be solved as readily as upon the

wooden sphere of the class-room. The observations necessary for this kind of work are not difficult, but they are made upon moving bodies and on this account must be made at a particular instant, and as a rule cannot be repeated as in other laboratories, where the student can make the observation over again by simply turning a micrometer screw or shifting a telescope. If cloudy weather intervenes the student may have to wait a week before he can get an opportunity to repeat the observation. The question of weather frequently makes it necessary to devote a much longer period to this subject than would otherwise be given. Then the computations are longer than those usually made by engineers in a single problem. The student must use his reasoning powers at every step in order to know why he is performing the operation; otherwise he will confuse it with some other work and get a wrong result. If he is to learn anything from this subject he must make his own observations and then reduce them. If the results come out wrong he should be made to repeat the whole problem over again. This takes a great deal of time on account of the reasons given above, but there is no other way to learn the subject.

The civil engineer does not need a knowledge of the telescope as an instrument for mere seeing; he is concerned only with measurements, and for this work the telescope is a part of the measuring instrument. An equatorial telescope, then, is not a necessary part of an observatory for a technical school. The instrument which every civil engineer owns, and which he always has with him, is the engineer's transit and this, I think, is the instrument with which he should make his first

observations. While it does not possess the stability and accuracy of the fixed instruments of the observatory, very satisfactory work can be done with it; time, latitude and azimuth—the three great problems which are taken up in this subject—can be solved by means of the engineer's transit with a fair degree of accuracy. The following is a list of the problems which, I believe, should be given in the course under discussion.

1. Time from single altitude of sun with sextant.
2. Time from equal altitudes of sun with sextant.
3. Time from single altitude of star with sextant.
4. Time from single altitude of star with engineer's transit.
5. Time from single altitude of sun with engineer's transit.
6. Time with astronomical transit.
7. Time with astronomical transit by least square reduction.
8. Wire intervals.
9. Value of one division of level with level trier.
10. Washington noon signals.
11. Longitude from determination of time and Washington noon signals.
12. Latitude from meridian altitude of sun with sextant.
13. Latitude from meridian altitude of sun with engineer's transit.
14. Latitude from Polaris at any time.
15. Latitude with zenith telescope.
16. Value of one division of micrometer.
17. Azimuth from Polaris at any time with engineer's transit.

18. Error of runs of micrometer microscope.
19. Azimuth with astronomical theodolite.
20. Azimuth of line.
21. Horizontal angles with sextant.
22. Use of solar attachment to transit.

I usually give the transit problems first because, as before remarked, every engineer has a transit. One of these problems is to determine the time from the sun with the engineer's transit; one is to determine the time from the stars with the same instrument. Thus at any hour of the night and at almost any hour of the day the engineer can obtain his watch correction and hence accurate time. With a little practice it is possible to obtain time in this way within fifteen or twenty seconds, which is accurate enough for use in the field. Latitude can be obtained from the sun at noon, and from any circumpolar star at night with an error not exceeding one half minute, which is accurate enough for latitude used in other computations, but it is not accurate enough to determine the position of a point upon the earth's surface; in fact this latter can only be done with the best astronomical instruments. The azimuth of a line can also be determined with a fair degree of accuracy from Polaris. The time necessary for these observations of azimuth is about one hour; sometimes less is sufficient. If an engineer surveying a piece of land would stay until dark one evening he would be able to determine the azimuth of one line and add incalculably to the value of the survey in after years. Determinations of azimuth can be made in this way with an error of less than one half minute of arc. As one foot subtends an angle of one minute at a distance of 3,437 feet,

an error of one half minute in the azimuth would mean an error of six inches in this distance. This error of one half minute is due to the fact that the instrument reads to twenty or thirty seconds only. By making repeated determinations of the same quantity it is possible to reduce the error of azimuth to a very few seconds and hence the error in a line 3,400 feet long to a quantity not exceeding one inch. This determination is close enough for any work not calling for the most refined astronomical observations.

Observations with the sextant will give more accurate results than with the transit, and as the sextant is a small portable instrument the student should learn the use of it. After making the observations with the engineer's transit and the reductions of the same, it is very easy to observe with the sextant and make the consequent reductions.

But the engineer may be called on to take part in the decision of more important lines, such as the boundaries between different countries or states, and hence he should have some knowledge of the more refined astronomical instruments. The instruments needed for this purpose are the astronomical transit, the zenith telescope and the altazimuth. The astronomical transit is used of course for the determination of time. As used in the United States Coast Survey it is a small portable instrument which can readily be carried from place to place. With it the observer can determine his clock error almost as precisely as with the large transit of the fixed observatory. Two or three nights of observing when the student has the instrument entirely to himself are necessary to learn its use. In deter-

minations of time, of course, he will not get very close results at first, but his error should always be in the fractions of seconds and increased accuracy will come with practice. The object of this course in college is to teach the student to use the instruments and to compute the results with intelligence. Large experience and practice must come at some later period. A number of the problems which should be required as a part of this general problem of the determination of time are: Wire intervals, value of one division of level with level trier, value of one division of micrometer.

The most accurate method of determining latitude is by the zenith telescope. For field use the transit is generally provided with a delicate level and reversing apparatus and can therefore be used as a zenith telescope. The student should be taught to select his own pairs of stars from the star catalogues, compute their places for the day of observation, and make all the observations and reductions. It has been my practice to require the student to make three determinations of latitude from three different pairs. Of course he generally tries a dozen pairs before he succeeds in getting results. The average of these three determinations of latitude is usually within one second of the known latitude, and no one result should differ more than three or four seconds from the true value. With the astronomical theodolite or altazimuth it is possible for the student to learn how to determine azimuth with the greatest accuracy. This work will be necessary in determining the azimuths of long lines. The student should understand how to determine the error of runs of the reading microscope before beginning observa-

tions. A fair knowledge of his watch correction is necessary. This can be determined by methods already given. If the student is anywhere near a telegraph office, he can probably receive the noon signals from Washington and obtain the longitude of his station. The method of doing this should be included in every course in practical astronomy.

The problems which I have enumerated seem to me to be the important ones in an engineering college. This work cannot be done without a proper amount of time, but the results, when the time is given, are extremely satisfactory, not only to the instructor in civil engineering, but to the student, who feels that he has obtained a knowledge of one of the most advanced subjects of his course.

EDUCATION FOR FACTORY MANAGEMENT.

BY HUGO DIEMER,

Associate Professor of Mechanical Engineering, University of Kansas.

It is only natural for men who have had no actual business experience to underestimate the value of an understanding of the problems involved in the organization and management of an industrial institution.

On the surface it appears to them that the entire subject may be settled by a few remarks on tabulation of data and the relative advantages of vertical or horizontal columns.

In other words the idea prevails that the subject is one which has to do with trivial details of accounting.

A suspicion seems to exist also that the men who are advocating the importance of due attention to the principles involved in organization and management in manufacturing may be promoters of some new pseudo-science to be put on the same basis with spiritualism, phrenology, or postage stamp collecting.

In the solution of those problems of organization and management which have to deal with the intimate connection between methods of manufacture and cost of production, the terminology employed must of necessity involve the use of expressions which but a few years ago were considered part of the exclusive language of the accountant.

A superficial survey of papers descriptive of the methods of management of a factory presents to the eyes of the pure technicist a preponderance of financial

and accounting symbols. To some educators these symbols lend the article the same uninviting aspect as do integral signs, differentials, and logarithms in a paper, to an ambitious business man seeking technical information about his industry.

It became plain some years ago that a purely commercial education was insufficient for the young man who expected to hold a position of responsibility in the management of an industrial enterprise. Whereas the line of promotion used to be through the ranks of the accountants and stenographers, the men with engineering education are to-day considered better material to draw from in selecting the managerial staff than any other class.

The reasons for this change are quite apparent on a little reflection. The accountant or clerk, no matter how good at systematizing, was constantly dealing with records of operations with which he had only a superficial acquaintance, while the engineer has had a training in the underlying natural laws governing the operations. A sound engineering education produces a psychic development also, adapted as a rule to the forming of sounder judgments than is produced by the purely commercial training.

Manufacturers have expressed themselves as being in great need of technically educated young men who have the capacity and training to fit them for positions which are executive to a greater or less degree.

The evolution of the modern engineering works has been accompanied by a large increase in the ratio of the number of what might be called the class of staff officers to the number in the ranks. These numerous

new staff positions have been necessitated by modern methods of determining sequence of operations, setting of time to do operations, establishing of wages and methods of paying them, tracing orders, accounting for stock, supplying material, keeping running records of costs of individual operations, and of factory expenses. It has appeared to many manufacturers and to many engineers of ability that the engineering graduate should find a natural and legitimate field in these new staff positions. On the other hand, there are members of the engineering community who would consider anything outside the confines of designing and experimental engineering as unprofessional. We have put into the category of what we esteem the thoroughly aristocratic sort of engineering, designing and testing. Yet it seems to the writer that even these most important phases of engineering education may be considered as not the end of the education, but the means towards the attainment of something higher.

It appears to the writer quite immaterial whether the work of the production department and the factory office be called engineering or by any other name. The gist of the matter is simply this: Here is a branch of productive industry in which there are the widest opportunities for a life of service as well as opportunities for the attainment of positions of importance. It is a branch of service for which it has been acknowledged that an engineering education affords the best possible training. This being the case, it seems our plain duty to consider the matter, particularly as it widens manyfold the opportunities open to the young men we are training.

Let us look back a little in the history of our engineering education, and consider the arguments that were advanced against shop work, and at an earlier date against drafting, as being fit branches for a trades school, but not for a college curriculum. If we look back a little further still, we find university professors a hundred years ago engaged in disputes regarding trivial details in discussions of matters which are to-day considered of little or no moment, and which we realize now were just as useless at that time. The traditional idea that subjects worthy of discussion by university professors must be abstruse, even if useless, still shows some traces of existence even at this late day. The theory of thermodynamics was taught in many schools some years ago in such a manner that few students could connect it with a practical engine test. The thoroughly sane methods of Boulvin, Donkin, Golding, Richmond, Ripper, and Reeves have been looked upon by some professors with suspicion, as attempts to evade calculus and differentials. The result of the practical methods of the engineers named has been, however, that the student sees some real utility in the study of thermodynamics.

We have adapted our engineering education to what some choose to call commercial methods, but which would better be called practical methods, so far as concerns many details of our instruction in design, in drafting, and in experimenting. And in so doing, we have in no way lowered our ideals or our standards. It seems therefore most proper that we should give some heed to the claims made by manufacturers that many of our young graduates are deficient in such essential

education as would enable them to handle practically the commercial problems which present themselves to the engineer entrusted with executive work.

Some eighteen years ago, in the course of a discussion by the American Society of Mechanical Engineers of methods of instruction employed at the Worcester Polytechnic Institute, it became evident that some of the prominent members of that society wished to draw a distinction between what they chose to call the profession of mechanical engineering, and the class of superintendents and managers in charge of the constructive departments. A sentiment prevailed at that time that an education less rigorous in theory and more extensive in manual training would be well adapted for the training of the superintendent class.

To see to what an extent the attitude in regard to such matters has changed, one has but to pick up a current number of the *American Machinist* or the *Engineering News,* and read one of the frequent want advertisements for a superintendent or manager. He will find many worded about as follows: "Wanted—Superintendent (or it may be Assistant Superintendent, or Manager). Must be technical graduate, capable of designing a certain line of machinery, and thoroughly conversant with modern methods of shop practice and factory organization."

Proprietors of engineering works want men with thorough theoretical training. But they demand also a knowledge of modern shop practice and factory administration. In view of these demands it would appear a fallacy that a man can become a mechanical engineer of higher order without needing to be thor-

oughly conversant with the best methods in the constructive side of engineering. The writer has had opportunities to do some practical work in factory organization, and from his observations and from conversations with manufacturers, he believes that in many of our engineering courses modifications may be made to adapt our graduates to the requirements of manufacturers. He believes that these modifications can be made without in any way detracting from the value of our engineering curricula as general culture courses.

These modifications may be classified as relating to the following four subjects:

1. Machine design.
2. Shop work.
3. Courses in shop methods and factory organization.
4. The organization of the mechanical engineering department.

As regards machine design, the student will have a far better conception of his work if he is required, in addition to solving certain problems by the application of the laws of mechanics, to prepare a complete itemized bill of material with weights and costs of all parts entering into the design. He should prepare also a plan of the shop operations, with their sequence, and an estimate of the time of labor required to execute the design. A study of methods would naturally involve the question of whether but one or a number of machines were to be built. The instructor in machine design will find data of this nature available for a number of designs that are widely constructed, such as

steam boilers, steam and gas engines, power punches, and the simpler types of machine tools. The writer believes there is more profit to be derived from going thus completely through two or three designs in the entire course than in any attempt to attack a multiplicity of problems. The foregoing remarks apply wholly to machine design and are not meant to apply to the study of mechanism or pure kinematics.

Secondly, shop work. The writer believes that the purely exercise part of shop work, covering forging, pattern-making, foundry, bench work, and machine shop, should be completed at the close of the sophomore year, or by the middle of the junior year at the latest. Shop work should be continued for students in mechanical engineering throughout the junior and senior years. This shop work should be taken without cutting down the work in experimental engineering or design. The objection raised that this makes the student's schedule too heavy is not well taken, since students will not have several afternoons per week off when they get into commercial work. The work in designing and in the engineering laboratory should not require work outside of the time for which it is scheduled, and if this practice is adhered to, the shop work can easily be carried.

The nature of the shop work for the junior and senior years would be two-fold: First, construction work from designs worked out by the students; secondly, works management.

In the case of most engineering schools, it is not feasible for the shops to be manufacturers of a standard article in quantity for sale. It is, however, quite

possible to manufacture a few machine tools or engines annually, which may either be disposed of in the open market, or utilized as part of the plant. It is a great advantage to the students to be able to follow the construction of a machine on the designs of which they have worked. The entire junior year's shop periods could be advantageously devoted to this type of work. The writer believes that students would be far better equipped for practical work if the shop time of the senior year were devoted to practical education in works management. To carry this instruction out successfully, the shop should bear as near a resemblance in its methods to the actual shop as does the banking department in a business college to an actual bank. The writer is aware that in most engineering school shops there is a certain amount of filling out of time tickets by students and a drawing of tools by checks. The principle that has brought about the introduction of these simple business methods in school shops should dictate a still further adoption of business system, discipline and economy. It is perfectly feasible to issue shop orders for all work, whether it be exercise work or construction work. Sequences of operations and standard times for doing them may be worked out by students and specified on order tags. Material can be drawn on requisitions from a stock-room where a perpetual inventory is kept. The shop can be divided into sections in which the upper classmen act as foremen and time-keepers. In his capacity as foreman in the school shops, the upper classman gains experience that will be of great value to him in practical work. He learns how to instruct other men. By determining

sequence of operations and time of doing them he becomes a judge and critic of all machine shop operations —another training that will be of great value to him. By making out factory orders and figuring times and costs, he will know better than to characterize as "red tape" these essential features of successful manufacturing.

With regard to the third class of instruction bearing directly on the subject of this paper, namely courses in shop methods and factory organization, such courses are given in a number of engineering schools. In most of them these courses are deferred until the latter part of the senior year. It would seem an advantage if the student could obtain instruction in shop methods in the junior year, while he is doing construction work in the shop, as previously outlined, and that a full course in factory organization and methods of administration be given in the senior year. A study of this latter subject will involve much collateral reading and an examination of systems adapted to small shops as compared with those fitted for large corporations, also a comparison of methods suitable for a company manufacturing a small range of standard machines with systems used where a wide range of sizes and varieties is to be constructed.

With regard to the last consideration mentioned, namely the organization of the mechanical engineering department, it seems almost self-evident that that student will be best fitted to fill successfully an executive position, who has received his preparation in an institution whose methods of organization and administration are most closely in accord with the methods of

modern engineering works. In order to accomplish this result and to institute the features that have been suggested under the heading of "shop-work," it is apparent that more assistance will be needed than is usually furnished in the shop of an engineering school. The man who has general supervision of shop work, whatever his title may be, whether he be professor of mechanical engineering, professor of practical mechanics, or director of shops, should occupy the same position with regard to his plant that the works manager of a manufacturing shop holds. This director's keenest interest will not lie in such matters as the purchasing of supplies, the attending to correspondence, or the necessary accounting forms of his department. He must be provided with competent assistants to whom he can turn over all the details of such work. He will devote his attention to his plant and its output, always remembering that the output is not machinery, but men. He will be constantly endeavoring to have the work of the various instructors dovetail well, and form a smoothly connected whole. Each instructor should be conversant to a certain extent with the work of the other instructors in the department.

The "foremen's meeting," so successful in practical manufacturing, will have its counterpart in frequent instructors' meetings.

While it is true that such a close-knit organization could be most easily maintained in a school of the German monotechnic type, we have no American prototype of these schools. Nor is it likely that we shall ever abandon the splendid shop plants of our agricultural colleges and state universities in order to adopt the

German system. The principle of individualizing and specializing which has been so fruitful of good results in research work in pure science in universities, is apt however to tend towards a scattering of the various instructors' energies if applied to the studies essential to constructive engineering. The writer believes that all branches connected distinctively with the art of constructive mechanism, namely those involving the design and construction and testing of both prime movers and machines, should form in our universities a distinct group or monotechnic school by themselves. Instead of unattached professors, each in entire charge of some single branch, he would have all these branches under a common head.

In replying to the criticisms of practical works managers, educators have too often taken it for granted that in order to accede to the demands of the industrial engineers, it would be necessary to decrease the time devoted to general culture subjects and the pure sciences. This is a popular fallacy among educators of which we need to rid ourselves. The leading men of our commercial and manufacturing organizations today are as a rule men of education and culture. They are men who have devoted a great deal of hard mental work to insure the success of their enterprises. It seems only reasonable that educators should exercise due consideration and appreciation of these facts, and make a study of successful commercial methods. The adoption of such methods into our engineering colleges will be by no means an assurance of the colleges' turning out men fitted to be phenomenal managers, but it will result in the providing of graduates who will be

more immediately useful and in no way less well educated.

The investigations involved in questions of factory management constitute work as fully entitled to be classified as scientific research work as any work done in university laboratories.

We cannot overestimate the value of these investigations. There is not another element in the industrial world so far-reaching and of such importance to-day as this question of modern management. The complete analysis of all details of labor and equipment has resulted in many cases in a doubled and tripled output with the same factory force. It has resulted in increases of laborers' compensation of from thirty to one hundred per cent. It has made room for an executive force from three to four times as large as that previously employed, and has created a splendid new field for technically educated men. And all of these results have been accompanied by largely increased profits to the owners of the works instituting these modern methods. These accomplishments constitute one of the most remarkable achievements of the opening of this new century.

Discussion.

Professor Raymond.—Mr. President, Prof. Diemer does not suggest where he will cut off the present course in order to put in the additional matter; in fact, he suggested he wouldn't cut it off at all; and in support of that statement or suggestion he tells us that the graduate in his after life hasn't several afternoons off during the week. I suppose the inference is plain. I think we all recognize the fact that

the graduate in his after life, as a rule (of course there are exceptions) won't have to work ten to eighteen or twenty hours a day. Some do. That is pretty nearly what will be put upon the undergraduate if he isn't given any afternoon off and is expected to prepare all his exercises for the next morning, during the evening. I think there might be some difficulty in working the school shop on an economical basis if the upper classmen were to be made foremen. That might work all right if the schools were small; but I mean in the larger schools. You may have forty to sixty or seventy juniors, and a larger number of sophmores. I am afraid that the proportion of laborers to foremen would be phenomenal. The advertisement does call for a graduate and one skilled and having knowledge of factory management, but I doubt if any such advertisement contemplates employing a fresh graduate who has acquired his ideas of management only in school. Indeed, I think that usually the employer would be inclined to send his son to a technical college if he expects him to take his place a little later, and then bring him home and put him through the shop. It seems to me that has been the attitude of a number of men of that class that I know. My idea is that the teaching of factory methods, the commercial end of it, is something that we cannot pick up now and add to our present curriculum. It is something that does not belong there any more than teaching commercial methods belongs to a classical school, the majority of the graduates of which go into commercial business after graduation.

PROFESSOR BAKER.—As I heard this paper I was moved to say that if we were thoroughly well acquainted with the bent of the student's mind and if we knew the field of his future activity and if we had very much more time, then we could give him a splendid education. But, under the circumstances, I suspect that we must be content with the things that are, and not the things that we might perhaps wish to be. Concerning the paper read, I don't know how it might be worked out in mechanical engineering, but I feel that it doesn't quite fit civil engineering, and therefore I am moved to make this remark: that we might do something to develop in our students executive ability by urging them to make use of such class and college appointments as come to them for developing their bent. If a young man is elected manager of a glee club or the ball team or something of that kind, if he can be stimulated by his instructors to use to his utmost the posssibilities of the position, it will do a great deal to develop in him what we call the executive side. I feel that we can not do very much by way of formal instruction in developing the executive ability of our students, but I think something can be done by inspiring them to make the most of class and college appointments that come to them.

PROFESSOR C. F. ALLEN.—I do not care to discuss this paper in detail, but I do wish to raise my voice for a moment in support of one thing that this paper deals with. There is a very rapid growth in our engineering colleges; there is a very rapid growth in the manual training schools that our president spoke of in his address; and the demand for that education will at times

leave men without an opportunity for securing positions purely in engineering. That is one side of it. Another side is, that there is, and there is going to be still more, a demand for men who will take care of our large manufacturing and industrial enterprises. In my judgment there can be no question that this demand must be met from the graduates of our engineering schools. I do not see how we can possibly get men elsewhere, in the literary college or from general business life, who have the qualifications that we find in the graduates of our engineering schools; this advantage that comes from engineering education is something that is useful wherever a man is placed. I believe it is true in general business; it is more particularly true in the administrative control of works that are semi-engineering in their character. I believe that the analytical quality of mind that is secured by the engineering training is something for which there is a demand in all kinds of business. I have been brought in contact, personally, with the practice of law, in which I believe the analytical quality of mind to be of superior value. I have no doubt that we shall find that our engineering colleges are going to be very largely patronized—more so than ever before; there is going to be a larger demand than ever for people to fill administrative positions, and I believe it goes without saying that those positions must be filled largely by our engineering graduates, the best men for the purpose; and I believe that as educators we should bear that general, wide principle in mind, that the time will come when that point of view will be of great value to us as teachers and to the students under us.

I do not care to touch upon the detail of the paper, but I do believe we should not lose sight of what I consider the large factor that is involved: if there is the demand and we are to meet it, the details will in some way arrange themselves in a good way.

PROFESSOR WILLISTON.—Aside from the demand for this kind of training outside—sooner or later schools and colleges will meet the needs of the people—I believe it is the business of the college and university in so far as the time allows, to teach the truth and the whole truth in regard to those things with which they deal.

The real criticism which Professor Diemer has made of the existing course in mechanical engineering, is that it does not teach the whole truth regarding the problems that it takes up; it teaches but a part of the truth and leaves the student to believe that that part is the whole. It teaches mathematics and the physical sciences underlying large problems, and ignores the economical science that relates to the same ones. And I believe that in omitting those things we are omitting part of the whole. We forget that the conditions, the status of the engineer, are changing. When mechanical engineering was introduced into the larger number of our schools, the engineer was largely a consulting engineer to the professional man. To-day he is largely the governing force of industrial enterprises. The corporations find it cheaper to employ their own engineers than to retain consulting experts, and there has been a very great change in this regard so that the profession, especially in mechanical engineering, is a very difficult profession as compared with what it

was twenty or twenty-five years ago. If we are going to live up to what we profess, we have got to try and train the young men for the profession as it is, and not as it used to be.

I was sorry to hear one of the speakers say that we would have to be satisfied with things as they are. I was sorry to hear him say that he thought the incidental occurrences in the student life of a few of our students, on ball teams, glee clubs and so on would give them the training which he thought could not be given by the organized system of instruction of the universities. It may possibly be true to-day, but I do not think it will continue to be true.

Regarding the system of foremanship, I would like to give a little bit of experience of my own. For the last four or five years we have made in the shop work of Pratt Institute the regular practice of having all of the students take turns in being foreman over the other students. It is feasible and gives most admirable results.

Many other of the features of shop work which Mr. Diemer referred to we have found possible to include in the two-year course; and if it is possible in the two-year course, it is possible in a four-year course. We haven't tried the experience of making the upper classmen foremen. I personally believe that the plan would work better to take turns and let every student of the class be foreman over his classmates, but that is a mere detail.

Professor Malverd A. Howe.—At a meeting of college professors held during last year, one of the most noted in the United States said that the technical educa-

tion was very well. It gave men a certain training which fitted them to take a certain position in the world; but the great positions, the executive positions, would always go to college graduates and never go to technical men, on the ground that they were broader men; that the technical men could not look beyond the details of their profession. While I do not agree with him, I think there was an element of truth in what he said; and if I understand Professor Diemer's paper, it calls attention to the fact that the education and training of our engineers should be such as to lead up to something higher and that the great administrative positions should go to these technical graduates, and that some enlargement and some preparation for this should be made in the technical college, and in that I most heartily agree with him.

Professor Vedder.—At a meeting of an engineering society in a western state about two years ago a simple question was prepared and presented to about a dozen engineers and constructors. At least two of them were men of national reputation, and all of them were employers of engineering graduates, some mechanical and some in the civil engineering line. The question was this: "In what chief particular do the schools come short of fulfilling your requirements as to the ideal graduate?"

They were asked to write out their answers, and they did. And nearly every one of those men deprecated the lack on the part of our engineering graduates of a knowledge of business methods. I felt at that time that it would be hard to find a place to do any educating in this line. I haven't found out a place for

it yet. I cannot understand how we are going to get anything into the top of the vessel which is filled to its capacity, without taking out something from the bottom; but I am satisfied that the demand is there, and that it must be met.

PROFESSOR TOWLE.—In the author's paper, and in the discussion, advocating this business instruction in the courses, they all seem to be worried about time. Many practical business men have said that to educate a man for the business side, he should not have the technical training, but should go into the works and learn the business there, because then he can get into practical affairs earlier in life. If the training that we give the students in the college will fit them better to cope with these things that the young men learn without going to college, if we can give him a few of those elementary principles that he must learn some time, he will be fitted to apply his technical work earlier in life,· as he will be fitted to take the responsible positions much earlier by having some inkling of this business life given him in his technical training. I think that many of these problems can be put into our work in the courses that we have now, by modifying them a little. There are many things, perhaps, that we can cut out and put in something more useful. If we can do this, we will help the student.

PRESIDENT WOODWARD.—There may be, as Professor Williston read to us from Professor Ayers's paper, certain fundamental principles which are of universal application, which may well be taught.

PROFESSOR DIEMER.—I have been gratified at the discussion of this paper; it manifests the interest that the members take in the subject under discussion.

With regard to the objection that in many schools the number of the upper classmen is so large that they cannot all be foremen, that is a mere matter of detail; they might not act as foremen all the time; part of the time they could act as foremen; and my idea was that this instruction should apply to those who expect to go into manufacturing work.

Managers of ball teams or glee clubs are, I think, hardly fitted to become manufacturers or managers of manufacturing establishments. I think young men who have acted in such capacities often have an unfortunately exaggerated idea of their own importance. Possibly they might make good politicians, but I don't think they would be adapted for good managers.

PRESIDENT WOODWARD.—I suppose the point after all is, can we have a normal school for business in an engineering college? That is what it is; it is a normal school.

ENGINEERING JURISPRUDENCE, AN ESSENTIAL IN THE ENGINEERING CURRICULUM.

BY ARTHUR H. BLANCHARD,

Assistant Professor of Civil Engineering, Brown University.

The value of any given course to the student is generally two-fold, its intrinsic cultural effect and the knowledge acquired. Cultural, as used above, pertains to mental discipline or to the development of one or more of the mental faculties. This view of culture should be borne in mind when admitting any course into the engineering curriculum, for it is essential that there should be a sufficient amount of the cultural element in the courses required to enable the student to graduate with a well-balanced mind, having all his mental faculties developed. Engineering jurisprudence, or that part of law in which engineers are particularly interested, unquestionably has this two-fold character, and hence should be included in the engineering curriculum.

Courses in the law of contracts were introduced into engineering colleges in the early nineties and have slowly been adopted by many of the leading technical institutions; for instance, a canvass of the 1903 catalogues showed thirteen out of thirty representative colleges from all parts of the country requiring such a course. Its non-introduction in many cases is due, first, to already crowded curricula, and second, to a lack of appreciation of its educational and professional worth. In this era of specialization, it is difficult to

crowd into four years all that the various specialists demonstrate is essential for the training of an all-round engineer. Although the curriculum may be crowded, the director of an engineering department should act with deliberation while weighing in the balance a course as general in its usefulness as engineering jurisprudence. That more educators have not recognized its professional value is due, without doubt, to the fact that they regard the treatment of legal questions as either the work of the mature engineer or that they lie outside the province of the engineering student.

The study of engineering jurisprudence by technical students is advantageous, first, because of the knowledge acquired, second, for the insight gained into business relations and methods, third, due to a cultivation of respect for the strictly legal clauses in specifications and other engineering documents, and fourth, on account of the development of reasoning power and independent thought.

Two queries should be considered in connection with the first advantage claimed. Is the knowledge obtained by the study of engineering jurisprudence valuable to technical students? Does the following statement of the late J. B. Johnson in 1894 apply to the conditions existing during the past decade, namely: "It is probably true that engineers fail as often in accomplishing the ends sought from imperfections in the specifications and in the contracts as from faults in the design itself?" Each question is a function of the other. If the interpretation of imperfect specifications, etc., results in costly errors and delays to-day it means that a large majority of engineers are unfamiliar

with legal forms and engineering law; it means also that, although many engineers see wherein this portion of their technical education was neglected, they fail to master the subject by individual effort. Unfortunately a large percentage of engineering graduates do not consider time profitably spent in studying subjects that were not alluded to in the engineering curriculum of their alma mater. It matters little what branch of engineering a student enters, sooner or later he encounters legal problems so interwoven with engineering technicalities that the average lawyer can give him but little satisfaction. One only has to ask the average technical graduate questions with regard to the difference between liquidated damages and penalties, conditions precedent, considerations, time of completion of contracts, and many others, all of vital importance in contracts and specifications, to appreciate how little is known with regard to the simplest principles of the law of contracts. It is not expected that students who have pursued a course in engineering jurisprudence will be capable of acting as expert advisors on complex legal questions. They will, however, certainly be able to steer clear of many of the common pitfalls and be better able to seek legal advice and deal more satisfactorily with contractors, who, as a rule, know at least fifty per cent. more law than the engineer who is directing the work and acting as arbitrator. Again, many mature engineers are called upon to write specifications and to draw up other papers requiring legal phraseology; and in this connection it should be remembered that we, as teachers of engineering subjects, are not merely laying

a foundation for the five years of subordinate service following graduation, but for the work of a lifetime.

The second advantage to be gained by studying engineering jurisprudence, that is, the insight gained into business relations and methods, will depend materially upon the method of conducting the course. This advantage will vary from a minimum by following closely the text of the treatise used to a maximum by using the same treatise as a foundation and by illustrating the fundamental principles by interesting cases taken from the law records of the various states. It is unfortunate that the average student is ignorant of the relations of the administrative office to the engineering office in any undertaking of considerable scope. Undoubtedly it is due to this lack of knowledge of business relations and methods that prevents many engineers from going into the profitable field of contracting or from seeking the many lucrative administrative positions for which they are ably fitted.

The study of law naturally must inspire a respect for its principles, thus, independent of its other advantages, it will be the means of establishing in the student's mind at the beginning of his career the important relationship between law and engineering. It is hoped that the common practice among many of the younger members of the profession of paying but little heed to the legal clauses in engineering documents will thus be obliterated. Knowledge and appreciative respect sometimes go hand in hand. If an engineer does not understand the meaning of a legal clause he cannot appreciate what its non-enforcement may mean; for instance, many of the costly errors made by engineers

acting as arbitrators may be directly traced to a woful lack of knowledge of, and respect for the legal principles underlying their duties.

The development of reasoning power and independent thought is the fourth advantage accruing from the study of engineering law. Perhaps it is unfortunate that many technical courses, as given, possess little cultural value. Courses such as those in mathematics, mechanics, design, etc., from the very nature of the subject surely develop other of the mental faculties than memory. It is doubtful if any course in the average engineering curriculum can approach in efficiency, when viewed from the standpoint of mental development, the course in argumentation as taken by the A.B. student. The course in engineering jurisprudence, if conducted on the lines suggested later by the author, will give the technical student a good drill in argumentation similar in character to the training received by his classical brother.

The course should preferably extend throughout the senior year, one hour per week, thus devoting about thirty hours to the subject. Ten hours could profitably be devoted to the consideration of real property, water rights, ownership, rights of way, boundaries, incorporeal rights and franchises, while twenty hours could be assigned to lectures and discussions on the law of contracts and a critical study of specifications and other engineering documents. The treatment of the law of contracts by a combination of the case and text-book method, the author has found to be productive of the best results; that is, the important points are emphasized by illustrative cases upon which each student

renders a decision, while the principles are obtained from the text of either Johnson or Wait. It may be said that the use of the case system requires more time than its advantages seem to warrant, but when it is remembered that the principles are usually so clearly explained in the text as to be within the comprehension of the average senior, it is seen that the hour can thus be devoted to an argumentative discussion of illustrative cases. This discussion serves to arouse and maintain the student's interest, emphasize the text and explain the more diversified principles, besides bringing the student into actual contact with business methods and relations and giving an opportunity for a development at least of the mental faculties.

Discussion.

Professor Raymond.—It seems to me there is not any question about the advisability of this sort of thing. It is a little hard to discuss the paper unless for those who do not give it. We do.

Professor Magruder.—I would like to raise the question whether in the judgment of those present it is better to have this course given by a lawyer who has had some contract with engineering, or, as Mr. Woodward said yesterday in the case of the Washington University, by an engineer. As stated in the paper, as I understand it, only thirteen colleges of the country give a special course in this subject, engineering jurisprudence, on contracts and specifications. In some of our colleges the subject is taught, but not in all colleges.

Professor Raymond.—There cannot be very much question about that. We get around it at Rensselaer by giving it by an engineer who recently became a lawyer; one of the graduates who wandered off into the law.

Professor Woodward.—I think it is well known that Mr. Wait is a man who was formerly a teacher of engineering and who is now a member of the New York bar.

Professor Raymond.—It would be all right if we could all have a man like Mr. Wait.

Professor Williston.—The expression of Mr. Wait's opinion upon this matter may be very interesting. I heard him make the remark in public not very long ago that in his experience with contracts that came to him in connection with his official position in New York City, the contracts drawn by the engineer were more accurate and less faulty than those drawn by the lawyer. His idea seems to be that the engineer who is not a lawyer is less likely to go wide of the mark than the lawyer who is not an engineer. I think the difficulty with the general introduction of this course has been the difficulty in getting competent teachers. I know of one or two institutions where courses of this character have been introduced where the work has been abstract because it has been given by a lawyer who knew nothing of engineering, and the students have not felt that they were getting very much out of it because the lectures were not close to the methods which it would be necessary to use. One hour per week I would not endorse. If only hour a week is necessary for the work, I believe it would be far wiser for the

professor of engineering to try to make himself competent to give that in connection with some of the courses which come five times a week.

SECRETARY WALDO.—I think that is practically what is done at Purdue University, where the professor of civil engineering gives instruction in contracts and specifications.

THE EQUIPMENT OF AN ELECTRICAL ENGINEERING LABORATORY.*

BY W. M. RIGGS,

Professor of Electrical Engineering, Clemson College, S. C.

A venerable old oak, upon which the sky has twice discharged its thunderbolts, stands a sentinel on the campus of a South Carolina college, separating the old order of things from the new. In the morning its shade falls upon the quaint little studio of that immortal statesman, John C. Calhoun, and in the evening its shadow crosses the intervening driveway and lies upon the electrical laboratories of Clemson College, one of the newly born of the Agricultural and Mechanical colleges of the country. The laboratory from which were taken the photographs to illustrate this paper is less than three years old. It may rightly claim to be one of the youngest of its kind, and this youthfulness extends not only to its years, but to its appointment and equipment as well. The writer wishes to disclaim in advance any desire to hold up as a model the laboratory from which the views are taken—they are presented simply as the concrete embodiment of a scheme, which abundant means and sufficient time have not as yet enabled us to carry to full completion.

Each laboratory must of course be designed with special reference to the work that is to be done therein. This paper contemplates a laboratory equipped primarily for undergraduate students, working in small

* Illustrated with lantern slides.

sections of ten or twelve men, each section being divided into two or three squads. The experience of the writer is that not more than two or three experiments can be carried at the same time without interference, unless there is much duplication of machinery and appliances. This statement of course refers to squads of the same class, engaged in about the same grade and nature of work. A greater number of widely different experiments could be carried on at the same time without trouble in so far as interference is concerned; but if the class and laboratory work are kept in synchronism, widely different experiments are not permissible. Apart altogether from the restrictions put upon the number of students that may be handled at one time in the laboratory due to insufficient equipment, is a still more serious limitation in the comparatively small number of men that a single instructor can handle to advantage. The wise instructor who, realizing that in the laboratory, help is a narcotic to be carefully administered, not promiscuously dispensed, and who lends a helping hand only after the student has gone down th traditional three times; who rather goes from man to man, asking questions that bring out the student's knowledge of the experiment he is performing—questions that make him think—and who incidentally keeps an eye on his precious instruments to see that an ammeter is not forced to try the duties of a voltmeter, or his millivoltmeter put across a two-hundred-and-twenty-volt circuit, will usually have his hands full with only a dozen men.

Laboratory Power Source.—Passing from this digression to the subject of the paper, "Electrical Labo-

ratory Equipment,'' a matter of prime importance is the power plant. Accurate results cannot be expected when electric power comes from an outside and necessarily fluctuating source beyond the control of the experimenters. Worst of all are those laboratories receiving their direct current power from trolley systems. A modern closely regulating high-speed engine is a necessary part of the power equipment of a laboratory. Such an engine belted to a polyphase alternator will furnish alternating current at a practically constant frequency, and through the medium of a jack shaft may be made to drive two direct-current generators, which operating normally on the three-wire system, may be connected singly, in parallel, in series, or in opposition, and thus be made to give constant direct-current power at almost any voltage. In polyphase work, on account of unbalancing, a separate generator is desirable to supply power for each experiment in progress. This is also largely true in direct-current work—each squad of workers should have a source of power entirely within the control of the experimenters and unaffected by the manipulations of the other workers. For some kinds of work, electrical power from an outside source will be found sufficiently steady and quite convenient, avoiding the necessity of starting up the laboratory plant. The power plant should be crowded into one end of the laboratory or placed in a separate room, in order that as much floor space as possible be reserved for the more mobile parts of the equipment. The direct current machines should be furnished with starting devices so that when power comes on from an outside source either may be run as a motor to drive the other

as a generator. The alternator shown deserves special mention on account of its suitability for laboratory use. It has six poles and thirty-six coils connected in sets of six. The terminals of these sets are brought to twelve binding post terminals on top of the machine. From these may be had single, two-, three- or six-phase currents with the choice of delta or Y connections. In order to make the connections more conveniently, the alternator is equipped with plug terminals and flexible plug connectors by means of which phase interconnection may be readily obtained and connection be had to any of the six lines that connect the alternator to the main switchboard. Accompanying the generator is a switchboard furnished with a complete set of edgewise indicating instruments suitably arranged to measure the two- or three-phase output.

Wiring.—The problem of laboratory wiring is one offering peculiar difficulties. No doubt every teacher present here can testify to the loss of time incidental to making the necessary electrical connections preparatory to the experiment. I do not believe in the policy of having all the connections ready made to the hand of the student, for by such a policy he loses much valuable experience; at the same time it is worse than useless to waste his valuable time, and rarer patience, in making connections at once difficult and preposterous. He should be required to do all wiring which has educational value, but mere "nigger labor" should be minimized. For example, if a student is conducting a generator test, driving the latter by means of a motor, it should be made easy for him to get his power connection from a convenient set of permanent power mains.

The generator he may well be required to wire up in toto. The use of heavy binding posts wherever possible can be made a great help in getting quickly the necessary connections. The illustration, together with the diagrams and sample switchboards, shows a system of wiring that some years of experience has proven quite satisfactory. Six heavy mains come in from an outside power house and make connection to the triple plugs on the switchboard. Under the floor run six heavy power circuits. From these laterals are run to floor, boxes furnished with fused knife switches and binding posts. These boards are of slate, let in below the floor level and covered, when not in use, by heavy slate covers. From four binding posts in these floor boxes other laterals are run, connecting to small switchboards on the side walls. These in turn have binding posts and plugs by means of which connection may be made to an overhead system of comparatively small mains run on the ceiling. These overhead mains are connected at intervals to plug boards, reached in making connection by a long-handled plug rod. For a main distributing switchboard the writer prefers a slate panel equipped with five eighths plug contacts. These contacts are about three inches long with three splits about two thirds of the way down, and are soldered into heavy copper or brass terminal blocks secured to the back of the board. Flexible cable soldered into five eighths tapered tubing is used to make the connection. Multiple plug contacts are furnished for lines likely to be used at the same time by a number of experimenters. The small overhead lines are protected by plug fuses, the larger lines by link fuses at the back of the board.

Any line may be plugged through the circuit breakers placed on the side panels of the switchboard.

Arrangement of Machines.—After trying several forms of track and various other methods, the writer has come to the conclusion that the most satisfactory arrangement of machines in constant use for testing is to have no fixed arrangement at all. The machines may be mounted upon substantial wooden bases, and these rolled about from place to place as the exigencies of the work demand. It is an easy matter to put two machines in place, and belt them up. All that is necessary to hold them in position is a little strip of wood tacked to the floor to resist the belt pull. The pulleys of all machines should be of such size as to have, at normal speed, the same peripheral velocity; in which case any machine may be used to drive another. This is a detail of some importance, for usually in taking generator characteristics it is most convenient to have as a driver an independent motor whose speed is accurately under control. Likewise in alternating-current work a D.C. generator makes a most convenient method of loading induction and synchronous motors. Light machines may be mounted on casters to facilitate moving, but this addition is not usually worth while and is liable to cause trouble by reason of the tendency of the machines while in operation to crawl and chatter. The slide gives a general view of the laboratory in which only the power units have a fixed position. All others can be moved about to suit the nature of the experiment. Endless gum belts of various widths and lengths are used for making the belted connections. These operate noiselessly and are quite efficient. The

machines used in testing should be of approximately the same size—not so large as to consume a great amount of power, nor too small to be representative of their class. A working balance must be maintained between the instrument and the machine equipment, otherwise many instruments will stand idle much of the time.

Artificial Loads.—For constant potential low voltage work, nothing equals in convenience and steadiness an incandescent lamp load arranged in table form for ready moving. If lamps are used that have reached their smashing point—and usually these can be had in large quantities—such an artificial load is quite inexpensive in first cost and in maintenance. For many other kinds of work, iron wire, and water rheostats are better suited. The water box is unequalled when fine and continuous adjustment is required. It is, however, inconvenient for indoor work, and except in small sizes cannot be moved about. For testing arc generators and arc transformers, wire rheostats in which all coils are of the same length and size give a much more convenient load than the less steady arc lamps themselves. For loading alternating current motors, nothing equals a direct-current generator working on a lamp bank or water box, or in the case of direct-current motors, pumping back on the driving motor.

Measuring Instruments.—Too much stress cannot be laid on the importance of furnishing to students the best instruments that money can buy and care maintain. A student cannot be expected to do good work if furnished with antiquated or inaccurate instruments. The modern direct-current instruments are to be pre-

ferred to some, which, while possessing theoretical advantages as regards accuracy, are, however—in the hands of the undergraduate student—no more correct than their commercial prototype, which latter can be read in one tenth the time. Too often is the end lost sight of amid the "mystic mazes" of the means, in which the obtaining of experimental data should be made as simple and direct as possible.

Performance of Experiments.—Having thus in a general way explained the laboratory equipment, several illustrations will be given to show its application to some of the usual experiments. The first shows a direct-current generator test for characteristic. It will be observed that the generator is motor-driven, the motor getting its power from one of the floor boxes which is connected to an outside source, or to one of the independently driven generators before shown. The generator mains are carried to a pair of binding posts in the same box and the output transferred to the switchboard on the side wall, where the measuring instruments are located. Here switches are handy to open or close the circuit. A lamp rheostat completes the installation. It will be noted that there are no long connectors over which the often distracted, and always hard-worked, instructor may trip and fall—or worse still—drag from the table to the floor some precious instrument. While convenient, the connections are still obvious and simple.

The second test shown is the Prony brake. Here the connections are essentially as in the last experiment. The field rheostat on the table is connected through the hanging wires and overhead circuits to the supply gen-

erator, and serve the operators to keep the voltage at the motor's terminals constant. The brake shown is in some respects unusual. The brake pulley is a hollow flanged copper structure into the interior of which water is admitted and allowed to evaporate. The outside surface is lubricated with soapy water fed through the syphon. The flying water is thrown from the outside flanges into tin shields, and thence runs to a receptacle from which it is returned to the elevated tank to be used again. The brake itself is of wood, lined inside with a poplar lagging. This lining presents to the pulley a homogeneous and velvety surface that does not stick or chatter.

The views shown are typical of direct-current working, the next two are of alternating-current work in the same laboratory. The first of these shows the connections and arrangement for testing the efficiency of an induction motor—the instruments in this case being placed on light tables near the machines. The second is the test of a General Electric constant-current transformer.

Testing and Calibrating Department.—A description of an electrical laboratory equipment would not be complete without mention of the necessary testing and calibrating department. The realm of the galvanometer must be removed from that of its husky magnetic fellow—the dynamo electric machine. The two adjoining buildings shown in our first illustration are for the purpose of separating completely the two classes of instruments and apparatus. The view on the screen shows the interior of the instrument laboratory—attention is called to the non-vibratory nature of all instrument

supports. A plug switchboard makes ready connection between any instrument in the room, or in the laboratory we have just left.

Lecture Room.—A class-room conveniently situated with reference to the laboratory is almost a necessity. It should be electrically connected to the laboratory, and should contain a counter sufficiently strong to support any of the smaller machines used in testing. A small jib crane will be found convenient in handling these. The counter shown in the illustration goes through the floor and rests on a solid clay foundation. The slate top is two and one half inches thick. The crane has a capacity of one thousand pounds. Binding posts on the back of the counter are connected through fused knife switches to mains having their plug terminals on the switchboard in the laboratory room.

Under the class-room is a basement in which is carried on the commercial photometry of arc and incandescent lamps.

DISCUSSION.

PROFESSOR GANZ.—Having had experience in teaching laboratory practice, I want to say that in reference to the wiring scheme, it is very nice for a small laboratory, but I find it impracticable for a large laboratory. I think that the aim should be to have a minimum of wiring, that is, permanent wiring. During the last year I have literally torn out half the wire, having the machines with which the students are at work brought right to the student so that the student makes his connection directly to the machines that he is operating upon, and not through the system of wiring. Furthermore, instead of bringing the switchboard

to the wall and connecting the terminal, I think it is more convenient in the large laboratory to have a small portable switchboard of five horse-power, except some of the driving units, which are larger, that can be brought in and have the instrument on your board and make the student connect from the machine to the instrument without any intervening wire whatever. I have found that to do away with permanent wiring is the thing we want to aim at in the dynamo laboratory. Of course I realize that we have got to supply current for a number of experiments. I have in my dynamo laboratory eighteen circuits running from a plug switchboard, running to different parts of the room, by means of which I can send the current to any part of the room.

In reference to the first part of the paper in which it is stated classes should be divided into squads of four or five each, I do not believe for laboratory work it is desirable to have more than two working on an experiment. Of course, in many large tests it takes three or four men to make observations, in which case a second group can be drawn in, but the experiment should be assigned to two men. And I think an instructor can teach half a dozen squads. I divide the laboratory work into groups, and before the students start a series of experiments in the laboratory, I have gone over those experiments up in the lecture-room and explained the details so that in the laboratory they can work independently. I go around the room and if I see a student who has made a wrong connection I refuse to point out the error. I think independence of work in this line is of very great importance and I believe where stu-

dents are working in groups of two, one instructor can handle half a dozen groups very comfortably. Make the student pay for any damage that may occur; he doesn't make mistakes very often. I remember only one burnout. He mentions that machines and apparatus should be "not too small and not too large." I should like to ask him what particular size he finds convenient? I have found five horse-power very proper size. The objection to very large machines is that a mistake made may be serious. I do not mind having a student throw a belt off a two or four horse-power, but I should on a ten or fifteen. The class-room should be adjacent to the laboratory-room. That is very, very important. As was very well shown in the last cut, machines can be brought in before the students so that the experiments may be exhibited to them in the lecture courses that I spoke of before. I believe that before the student enters the laboratory to do the experimental work he should have been given an experimental lecture course and every lecture gone over in the laboratory work independently as far as possible, and I believe the best results are obtained in that way.

President Woodward.—I understand that you speak from eight years' experience at the Stevens Institute?

Professor Ganz.—I do.

Professor Caldwell.—The last speaker voiced a number of the statements which I had in mind to make in regard to the paper. There is one other point I would like to add. It is in connection with the question of damage to instruments; we also require our students to pay, but we have adopted, the last year or two, a scheme which has proved very successful, of using

enclosed fuses about the laboratories, and charging the students for the fuses blown. That brings the matter home to them a great deal more frequently, although not as forcibly as the burning out of the instrument does. We find it works very successfully, indeed.

PROFESSOR GANZ.—I think the students ought to be so thoroughly drilled in the protection of these amperemeters as to make no mistakes, and make them pay for the amperemeter but not for the fuse; a great deal better object lesson. In eight years' experience, one single meter has been burned out in the laboratory; and an ammeter is a matter of fifteen dollars nowadays, and it is a good lesson for them.

PROFESSOR WOOD.—I feel very much like a freshman in a good many of these discussions, being one of the younger men, but there is one thing that a few years of this kind of work has taught me, and that is the importance of drawing the right conclusion from the laboratory work and presenting those conclusions so that they will be of value to a man after he leaves the laboratory, and in fact all his life.

PROFESSOR RIGGS.—In this scheme of wiring it does not concern the student where the power comes from. The dozens of times he connects up a motor for driving a generator, he is making a test upon the generator and it is presumed that he can connect up a motor properly. It doesn't concern him primarily where the power is from. With the exception of such wiring as I have shown, there is no permanent wiring at all. All other connections are made just as explained, by means of cables and loose wires, all above the floor and in plain sight.

I stated in my paper that I object seriously to any instructor who goes around promiscuously dispensing help. I do believe that more harm is done that way than in not helping enough. I believe the instructor can best employ his time in passing from student to student, in asking questions that bring out his knowledge, and I have followed this method; I never tell him where it is wrong; I tell him that there is a wrong connection, but do not tell him how to correct it.

In reply to the question as to what size of machines, should be used, I would say that the unit I have selected is about two or three kilowats, and for generators three to four H.P. for motors.

THE ADVISABILITY OF INSTRUCTING ENGINEERING STUDENTS IN THE HISTORY OF THE ENGINEERING PROFESSION.

BY J. A. L. WADDELL,

Consulting Bridge Engineer, Kansas City, Mo.

The absolute ignorance of students at engineering colleges, of young engineers, and, it must be confessed, also of many old members of the engineering profession, concerning the history of civil engineering and the names of the prominent engineers of past and present times is simply astounding!

Why should such a deplorable state of affairs exist?

Some may say: "Because ours is such a recent profession, it being in fact the youngest of all the learned professions." Although in one sense this statement may be correct, still the excuse will not suffice; for civil engineering is in fact one of the oldest, if not actually the very oldest, of all the professions. In prehistoric times the men who dammed water to irrigate their fields, or who crossed streams by felling trees or by piling rocks in their beds for stepping stones were certainly the engineers of those days—and it is more than likely that there were then no lawyers, doctors, or clergymen, because law, medicine, and religion were probably unknown.

Others may reply: "Ours is such a busy profession that its members are ever occupied with the present and looking to the future, so have no time to spare for considering the past." This is a good reason but a

poor excuse. Moreover, now that the general public recognizes engineering as one of the learned professions, it behooves its members to become conversant with its history and development and familiar with the names and careers of its most prominent men.

Others may say: "The blame lies with the professors of engineering in the technical colleges, who pay no attention to such matters as engineering history." This is true in a way; but the professors might reply: "There is no time in the curriculum to devote to such matters, for there is already more in our courses than can be crowded into the allotted time"—a lame excuse, indeed, because either the time should be increased or something of less importance should be left out—preferably the former. Or the professors might answer: "How can we teach the history of engineering when there is not a single book of any value upon the subject, and when we ourselves are nearly as ignorant thereon as our own students?"

Now we are arriving at the gist of the matter; for if there were in existence a thorough, reliable, and exhaustive history of civil engineering, it is probable that every professor in every technical college would use it to a greater or less extent, and most of them would adopt it as a text-book.

But who is to undertake the stupendous task of writing such a treatise? No one man could do it in any reasonable time; and, moreover, no one man is capable of doing it properly; so, if the book be written at all, it must be prepared by a combination of writers.

Now what combination of engineers and technical writers is as well fitted for such work as the members

of the Society for the Promotion of Engineering Education?

And what a grand enterprise it would be for this Society, one that would make it famous for several generations throughout the entire English-speaking world. Aye—more than that—throughout the whole civilized world because such a valuable book would certainly be translated sooner or later into the principal foreign languages.

Such being the case, let this Society appoint a committee to first consider the advisability of the Society as a body undertaking the writing and publication of "The History of Civil Engineering," using the latter term in its broad sense so as to cover all branches of engineering except the military; and, if the decision of the committee be favorable to the suggested publication, let it outline in its report a policy and modus operandi for the Society to follow in order to produce the best possible history in the reasonably shortest time.

The following are some suggestions that the writer would offer concerning the proposed work.

1. That the subject of civil engineering be divided into a number of heads or topics representing the different kinds of engineering work, and that these be apportioned among the members of the Society, one topic being given to one member, or perhaps in certain cases to two or more.

The following is offered as a preliminary list of topics, to be amended or increased as may seem good to the committee.

Bridges.

Concrete and cement.
Dams.
Electrical engineering.
Engineering education.
Foundations.
Gas motors.
Harbors.
Hydraulic motors.
Landscape engineering.
Manufacture of iron and steel.
Masonry.
Mechanical engineering.
Mining engineering.
Power transmission.
Railroading.
Rivers and canals.
Roads, streets and pavements.
Roofs.
Sewerage and sanitary engineering.
Ship-building.
Steam engines.
Steel buildings.
Surveying and geodesy.
Tunnels.
Water supply.
Wind motors.

It is to be noticed that this list is made alphabetically, which is the arrangement that the writer would suggest for the book.

2. That an editing committee of three be appointed to choose the various writers, apportion their subjects, limit the number of words and illustrations for each

subject, check, correct and finally approve each finished paper, and attend to the publishing of the entire book, the proof-reading of each article, however, being left to the writer thereof.

3. That the committee collect to as great an extent as possible the portraits of the leading engineers of the past, and reproduce them throughout the book in the papers devoted to their principal specialties or finished constructions.

4. That the committee collect also photographs of a number of the principal constructions pertaining to each division of the book, and use them for illustration.

5. That the various writers be advised to call for suggestions or aid on their work from other engineers, whether the latter be members of the Society for the Promotion of Engineering Education or not, and from the various engineering societies both at home and abroad.

6. All papers should be written with the understanding that the main usefulness of the book will be through its perusal by students in technical schools.

7. It will be necessary for all writers to treat as fully as practicable the work of foreign engineers as well as that of their American brethren.

8. Only reasonably authentic history should be given; and wherever there is any doubt whatsoever concerning the correctness of any statement, the said doubt should be clearly indicated, and the sources of information stated.

9. The book throughout should be written in a most readable style. It should be thorough, concise, accurate, and complete without being too lengthy.

10. The various writers should keep in close touch with the editing committee as their work progresses, so as to avoid to as great an extent as possible the necessity for changes.

11. No expense should be spared to make the book complete and to publish it in first-class style.

12. The selling price should be a minimum; and if eventually there be any profit, it should be divided into two equal parts, one part going to the general fund of the Society, and the other being divided equally among the writers of the various papers, including, of course, the editing committee.

13. All actual cash expenditures by the writers in preparing their papers should be repaid immediately by the Society from a preliminary fund established for the purpose. This fund should be used also in securing portraits of the old engineers and photographs of important engineering constructions.

14. It would not take a large sum of money to publish the work, because the type-setting, paper, printing and binding need not be paid for till after the book is issued; and the initial sales would certainly cover all such expenses.

15. The sale of the book, even at the outset, would be immense; and afterwards the demand would be both large and constant, rendering the venture a financial success and the work the most popular and widely used of all engineering treatises.

Discussion.

[The Secretary received a large number of written discussions of Mr. Waddell's paper. It has not seemed

necessary to the editors to print all of these discussions in full, but such extracts as will put the reader in possession of the numerous opinions and arguments that were elicited bearing upon the important proposition submitted by the essayist.—EDITORS.]

W. H. BIXBY.—"I feel that such a compilation and publication is exceedingly desirable by some responsible party or parties, and I would gladly see it done if possible by the Society for the Promotion of Engineering Education."

CHARLES PURYEAR.—"The chief benefit of such a course of instruction would, in my opinion, be derived from the fact that it would enable the engineering student to view his intended profession in true perspective and give him a definite idea of the relation of the engineer to society.

"I believe the plan proposed for bringing out the history is, on the whole, a good one; but I think there would be lacking the unity which should characterize a *book;* and that the result would be not a 'book' in the best sense, but a cyclopedia of engineering history.

"It would, in all probability, be too bulky to admit of its being given a place in the already crowded curricula of engineering schools. But the material once gathered and published in a form acceptable to practicing engineers, it would be an easy matter to prepare a text giving the essentials of the subject in condensed form; this might well be given a place in the schools.

"I think it would detract from the book to insert photographs of engineers; and I disagree with the suggestion that 'the sale of the book from the outset would be immense.'"

S. N. Williams.—"I wish to express my hearty approval of the new and admirable thought of Professor Waddell. The wonderful achievements of engineering skill have not been properly appreciated by humanity as compared with like productions in other professional lines, while the known modesty of engineers has caused an unwillingness to press their claims for recognition on the public which has been surfeited with histories of all kinds and persons excepting those who have in an engineering way contributed so materially and quietly to human welfare.

"The time has fully come for this neglect to be remedied, and as the justice of Professor Waddell's statements will immediately commend itself to the members of our Society, I trust steps will at once be taken to prepare such a history along the lines he recommends.

"This movement harmonizes admirably with the grand offer of Andrew Carnegie to build and maintain a home for the various engineering professions, thus doing a noble work in educating the people of America to a proper recognition of the great service engineering has done for the world which has never been more conspicuous than at the present time.

"I favor also the detailed suggestions made for the preparation of this history."

L. S. Randolph.—"The writer is heartily in accord with Mr. Waddell in his ideas, and believes that such a history as he advocates will be extremely valuable. One of the great values of history and the study thereof, is that it gives a man more definite conception than he will otherwise get, and there is no doubt in the

writer's mind that definite conception in regard to what constitutes an engineer and what an engineer should be, are not only badly needed among the people generally but also among those whose duty it is to train and teach engineers.

"The multiplicity of scholastic degrees with the word 'engineer' attached, and the planning of many of the courses of instruction in engineering, are proof positive of the absolute necessity for some more thorough knowledge of the work of an engineer. The civil engineer retains more than any other class his high position. By civil engineer is meant all of those included in the broad term of civil engineers, with the exception of what are sometimes called dynamic engineers. In one or two of the old schools of engineering, which for thirty or forty years have been turning out civil engineers and which therefore are thoroughly acquainted with the history of the same, the course of instruction is well fitted to the work to be accomplished and the professional standing of those practising the profession is more thoroughly recognized.

"The danger comes from those who, having for their own work nothing of the training and preparation which is given to the civil engineer, seize upon the title of such high renown and boldly appropriate to themselves the accompanying unearned honors and emoluments. We have the man who fires the boiler and pulls the throttle dubbed a locomotive or stationary engineer; we have the woman who fires the stove and cooks the dinner dubbed the domestic engineer, and it will not be long before the barefooted African, who pounds the mud into the brick molds, will be calling

himself a ceramic engineer. Those of the teaching profession have seen how this thing goes and are familiar with the tonsorial artists who are called professors, and the dancing masters who have the same high sounding title.

"In order to place the matter briefly, it can be said that the profession of engineering is to-day at the parting of the ways. If the engineer is to fulfill the definition which is so generally accepted, 'as one who applies the discoveries of the scientists to the structural needs of mankind,' something must be done at once, and there are but two ways of handling the question. One is boldly to adopt a new title and leave the title of engineer, which is rapidly falling into disrepute, to the locomotive engineers, the domestic engineers, the sugar engineers, etc., who have caused its fall; or to begin a campaign of education which shall bring clearly before the public, before our college presidents and boards of control, what the engineer is, or rather what he should be. I know of no better place for this to be done than in this Society, and of no better method than the preparation of a history of engineering as outlined by the author of the paper."

H. W. TYLER.—"Your circular note of May 21 in regard to the advisability of instructing engineering students in the history of the engineering profession is duly received. The idea impresses me very favorably, as tending to give engineering students the breadth of view they need but do not always gain. I should, however, doubt the wisdom of an attempt on the part of the Society to compile and publish a treatise."

F. H. Robinson.—"I am sure there can be no question regarding the desirability of a work on the history of the profession. It would be valuable not alone to the students in technical schools, but to the entire profession. As it does not seem at all likely that an individual will take the matter up, I hope our Society will promptly do so."

A. F. Nesbit.—"I have no doubt as to the advisability of thoroughly acquainting our students with the history of the engineering professions, either by actual class-room instruction, or by requiring them to purchase recognized literature concerning the same. To illustrate this latter method, I try to put into the hands of my electrical students the best information regarding subjects, terms, phrases, history, etc., by requiring each one of them, at the outset of their course, to purchase the enlarged edition of Houston's 'Electrical Dictionary.' Whether the result can be best attained by attempting, as Mr. Waddell suggests, to include under one head, such topics as electrical engineering, mechanical engineering, mining engineering, etc., so broad in themselves, or whether it would be better to differentiate and publish separately, I am not prepared to say. I believe, however, that some action toward the end Mr. Waddell has in mind would prove of value not only to myself and students, but to a large body of readers."

E. L. Corthell.—"If the profession could have a history of itself such as Mr. Samuel Smiles wrote years ago in his 'Lives of the Engineers' it would be of great value to the young men who are coming forward in our profession, but it should be written in an attrac-

tive style such as Mr. Smiles' was, and by someone, or by those who are capable of writing in a popular manner. I am in hearty accord with the project."

STANLEY H. MOORE.—"I heartily endorse the idea; one question, however, arises in my mind. If the Society undertakes the publication of such a volume, why limit it to civil engineering and give but one chapter to mechanical engineering? Why not publish a work, on the excellent plan outlined, and call it a History of Engineering?"

WALTER G. BERG, Chief Engineer, Lehigh Valley R. R.—"I consider Mr. J. A. L. Waddell's suggestion for the compilation and publication of a 'History of Civil Engineering' as a very valuable one. The advance in civil engineering, like in most professions, has been by a process of evolution and experience gained not only in experimental work but in actual new construction works, built on new ideas and conceptions. Hence the history of the profession, if written not just as a record of names and facts, but as an analytical treatise of the principles and important steps in the evolution of the art, will be of great value. In addition, it might be truly said that we to-day owe it to the pioneers in our professsion to record their work and to give due credit for their achievements accomplished at a time when the auxiliaries of the profession, such as technical literature, accurate instruments, records of results of others in similar fields, were practically nil."

A. H. FULLER.—"The writer feels greatly interested in Mr. Waddell's suggestions concerning the publication of a history of civil engineering and hopes to see the Society push the matter at the annual meeting.

"The writer would suggest that irrigation engineering be added to the topics already offered, and also that the topics be grouped by subjects instead of alphabetically. Under the arrangement offered by the author the matter appearing under hydraulic motors (to take a specific example) might well be expected under water power development and closely associated with rivers and canals, and water supply. With a suitable index, would it not be unwise to separate kindred subjects into an alphabetical scheme simply to make a doubtful improvement in the general arrangement?"

W. L. MIGGETT.—"I of course think that a history of engineering would be of great value to the profession in general, but whether it could be used as a text-book in schools is more or less doubtful because of the already numerous subjects that seem to be essential in an engineering training. His plan for compiling such a history seems feasible and I would be glad to see the Society take the proper steps to have the matter given thorough consideration."

ELLERY W. DAVIS.—"I believe the Society would give valuable aid to both teachers and students by the preparation of some such work as Mr. Waddell suggests. We better understand present practice by seeing how it came about. We better understand how to improve that practice, *i. e.*, actually get improvement adopted, if we see how this has been done in the past, and, moreover, not infrequently we shall avoid serious errors by seeing what similar errors have led to in the past. These are direct practical results. Hardly less important is, however, the enthusiasm created by the

study of the struggles of the great ones who have preceded us."

Palmer C. Ricketts.—"I have read with interest the abstract of the paper of Mr. Waddell on 'The Advisability of Instructing Engineering Students in the History of the Engineering Profession.' His criticism of engineering schools is to some extent just. The shortcoming of the schools in this respect is, however, due partly to the same cause which compels the omission of other valuable materials—to want of time. And I do not regard this as wholly a 'lame excuse.' Everything must give way to important fundamental principles and the field is so wide, in a general engineering course, that much interesting and valuable matter must be omitted because it is not of fundamental importance.

"I agree with Mr. Waddell that the Society would be well employed in the production of a history of the engineering profession. It would in this way, I think, do more work of value to the schools and to the profession than it has heretofore been able to accomplish."

B. F. Groat.—"I favor a brief course in the history of the subject, and the publishing of a text-book by the Society, if it proves, upon careful investigation, to be a feasible thing for the Society to do."

Mansfield Merriman.—"I am not prepared to agree with the author that teachers and students in our engineering colleges are 'absolutely ignorant' concerning the history of engineering. On the contrary, I am of the opinion that the teachers know many things about the great engineers of the past and present and that they impart some of this knowledge to their stu-

dents. I cannot admit that 'there is not a single book of any value on the subject,' although I am quite willing to agree with the author that a comprehensive history such as proposed would be of much value. The publication and sale of a historical volume of this kind is, however, a financial problem of some difficulty. It is not at all probable that 'most professors of engineering would adopt it as a text-book,' nor that 'its sale would be immense,' nor that the initial sale would be sufficient to cover the expenses of type-setting, paper, printing, and binding, and least of all that it would certainly be translated into the principal foreign languages. The enthusiasm of the author appears to have led him to make statements which calm reflection cannot warrant.

"The main thought of the author is an excellent one, but I doubt if it is expedient for this Society to take any formal action upon it. There is ample room in our Proceedings for the publication of historical papers, and I trust that some may appear in future volumes. A subject cannot be thoroughly understood until its historical development has been understood, and, acting upon this idea, it has long been my custom to give historical information in lectures to my classes. Formal presentations of the history of the different branches of engineering are, however, not as numerous in print as might be desired, and it seems to me, if one or two of these were read at each of our annual meetings and published in our Proceedings, that the cause of sound engineering education would be promoted."

DANIEL CARHART.—"It is time that the writing of such a history be undertaken. We could use advantageously such a work here, and I have no doubt every technical school and scores of engineering offices would want the book. Besides, it is due the great profession which we represent that a detailed account of its beginnings, its growth, its present proportions, and the men who have contributed to make it what it is should be presented in an attractive manner as to matter, page, and cover."

F. P. SPALDING.—"Mr. Waddell's paper introduces a very important subject. There can be no question as to the desirability of instructing our students in the history of the profession. Probably, nearly every teacher of engineering does a little in this direction, by teaching certain subjects through tracing the gradual development of present practices and theories from their beginnings. Some subjects are most effectively handled in this manner, and little digressions into biographical sketches, or notes of related events, may often add interest and charm to the subject. Probably the detailed history of the development of a particular field of work would be best given in connection with the treatment of the subject of which it is the history, but a connected discussion of the history of engineering as a whole, with some account of the lives of the men who stand out most prominently, would be of immense value, through the aid it would give in eliminating the mere business idea and inspiring the young men with the love and reverence they should feel for the dignity and traditions of their profession.

"Mr. Waddell suggests that in writing the proposed

history, the field of engineering be divided into certain specialties, each of which should be separately written by a man qualified for treating it. This would undoubtedly be the method best calculated to get a connected account of the development of engineering science and practice, and would place at our disposal the information necessary to produce the wider history of engineering as a whole, and of the men who developed it.

"The publication of these special histories as separate small volumes in a series under a single editor would seem preferable to a single large volume. And a second series of engineering biographies would be of equal value.

"For a text-book upon which a systematic study of history of engineering, in the schools, may be based, neither of these could be suitable, but some one must take the materials thus brought together, and carefully arrange it into a connected discussion, showing the all-round development of engineering science and practice and the relations between its various parts.

"The writer does not now feel able to express an opinion concerning the desirability of the Society taking the matter in hand. It should first be thoroughly discussed and understood. The publication of such a work should not be difficult to arrange as a private enterprise; it only needs to be started.

"The proposition is worthy of serious consideration by the Society, and it is suggested that a committee should investigate the matter, more in detail, as to its feasibility and business arrangements, before any final decision is reached."

J. L. Harrington.—"The paper entitled 'The Advisability of Instructing Engineering Students in the History of the Engineering Profession,' introduces a subject which is now almost universally ignored in the technical schools, and which, while seemingly non-essential to instruction in current practice and the theory upon which it is based, is fundamental in the broad scheme of engineering education.

"The theory and, later, a little of the practice of an important branch of engineering is now presented to the student with little or no introduction; that is, he begins to study the subject in the present, and practically ignores the previous stages of its development. Verily the last comes first.

"This procedure leads to a groping habit of mind. The student vaguely wonders about the earlier steps in the development of the subject in hand, but finds his time well filled, and leaves investigation to the leisure of his later years; and, if he be successful, he rarely finds that leisure available for the work.

"The study of the history of engineering, be it ever so brief and incomplete, will lead to the investigation of the work of other engineers and often, in consequence, to the avoidance of error into which others have fallen, and to a great saving of labor in duplicating what has already been well done. Often, too, there will be discovered an excellent foundation for successful work.

"It is manifestly impossible to go deeply into the history of any subject; its proper presentation often requires more time than is now available; but a brief and well-presented introduction would add greatly to

the student's interest and zest, and would inform him where to find the material for, and impress upon him the value of a thorough knowledge of the various steps in the development of the subject under consideration. In rare instances such an introduction is presented in the text-book. The first chapter in Dugald Clerk's volume on 'The Gas and Oil Engine' is an historical sketch derived largely from the patents issued upon gas motors by various countries. But such a plan is not feasible, because a number of different text-books will always be used, and to preface each with a history of the subject would be to multiply greatly the labor and expense of producing the book.

"It would be best, in the writer's opinion, to produce not a single volume or work embracing the history of all engineering, but a number of monographs, each devoted to only one subject. The publication of the English Men of Letters and the American Statesmen Series indicates how successfully the work might be carried out. This plan would make portions of the work available within a very short time, for there are undoubtedly members of the Society who are prepared to produce at once monographs on the subject of their particular interest; it would not draw heavily upon the Society's resources, and it would allow time for thorough treatment of the more important subjects. A history of each subject, so brief that it would read like the generations of Noah, would produce a volume so large that it is not to be considered. The previously mentioned introduction to Dugald Clerk's 'The Gas and Oil Engine' is little more than a catalogue of patents, but it occupies twenty-eight pages of good

size. Yet the subject is simple, indeed, in comparison with bridges, the steam-engine, the electric generator and motor, or ship-building.

"Again, in the production of a work of encyclopedic character, the writer's individuality is lost, whereas in the monograph bearing the name of the writer, there is every incentive to work of the highest order. Hence it is probable that separate treatment of the various subjects would produce results much more satisfactory to the writers, to the students, and to the Society, and much more beneficial to the cause of engineering education."

E. J. McCaustland.—"Mr. Waddell's paper advocates two very distinct propositions—one of these the writer regards as of very doubtful value, but with the other he most heartily agrees.

"First, as to the advisability of instructing engineering students in the history of the engineering profession. The author has pointed out one of the chief objections to the technical schools taking up this work, viz., lack of time. This objection however can not be disposed of by saying that it is a lame excuse and that the remedy is to increase the time, or that something of less importance should be left out. We are rightfully calling for a broader education of the engineer; for a widening of his horizon beyond the purely technical field of his profession; for a training that shall arouse his sympathies for humanity, quicken his impulses for good, and prepare him to be a leader of men.

"The chief obstacle which lies in the way of fulfilling these needs is the lack of time which young men

give to college work, and the practical impossibility of requiring them to devote more time in the present stage of the growth of engineering education. In this time, the purely technical has crowded out all else, and still clamors for more space. The proposition with which we are confronted then, is this: With no increase of time in view, and the schedules already full to overflowing with technical subjects, is there anything that could wisely be omitted in order to make room for the history of engineering? Mathematics, physics, chemistry, geology, mechanics and hydraulics, surveying, bridges, railroads, sanitation, engineering jurisprudence, steam and electrical machinery, etc., all crowded into a short term of four years are fundamental in an engineering course. No one of these is of less importance to the student of engineering than the history of his profession, and hence we have no justification in cutting out any one of them.

"The alternative would be to increase the time. But with increase of time comes demands for a place in the curriculum from other subjects which the writer believes to be of vastly more importance than the history of engineering. The necessity for more extended and more careful training in English is being forced upon us, and this training should, to a very great extent, precede all technical work. No student should be allowed to enter technical classes, who lacks the ability to express his thought on the written page in simple, but correct and concise language. Is there any question as to the comparative value to the student, of a thorough knowledge, and facility in the use of his mother tongue, and a like knowledge of the history of

the engineering profession? If a place can be made for it in the curricula, let us have further training in English. Even when this is accomplished, there is still political science, general history, current history, philosophy, or public speaking, any one of which will do more to broaden and develop the young student of engineering than would the study of the history of engineering. Engineers, as a whole, are no more narrow in their views of life, its privileges, and its obligations, than are the members of the other learned professions; nor are they any more likely to confine their whole interests within the restricted boundary of their own work. Their field is as wide, or wider, than that of law, medicine, or theology. But the great work-a-day world, strenuous and self-centered, is more generally affected by questions of law, of medicine, or of theology than by questions of engineering, and hence the engineer is somewhat restricted in the field in which his efforts receive recognition. But this very fact should force upon the attention of engineering educators the necessity of training their students to be essentially men of their times, or in advance of their times. This can not be accomplished unless his education takes him beyond the field of technical work and opens his mind and heart to the ideas and ideals which are moving forces in the minds and hearts of millions of his fellow beings.

"One other objection to the teaching of the history of engineering is noted by the author, that, he suggests, might be met by the compilation of a proper text. It occurs to the writer that very few professors in the technical schools could teach the history of engineer-

ing, no matter how suitable the text might be. To teach history of any sort well requires a great degree of enthusiasm on the part of the instructor, and a like degree of interest on the part of the student. Unless the student had interest and enthusiasm, the professors are few who would have the ability to inspire these feelings in him. If he had this interest and esthusiasm, a well-written text would suffice for his needs and he would get great good from its perusal.

"Here, the writer thinks, is the justification for Mr. Waddell's suggestion. We should have such a history as a record of past achievement in a growing profession, to interest and inspire both young and old, but such history has no place in the curricula of the modern schools of engineering. It follows, therefore, that with the main proposition of Mr. Waddell's paper the writer is most heartily in accord. There is a definite and growing need for such a history as he outlines in his paper, and this Society is in a position to undertake its compilation and publication with every promise of success. The suggestions offered by the author are, in the main, very good, and the writer is in favor of the appointment of a committee for the purpose indicated."

Oral Discussion.

Professor Williston.—Thought the Society very nearly of a mind that it is exceedingly desirable that there should be more literature on the subject. He thought it also an exceedingly difficult task, and probably one which is not practical, in the way in which it is suggested, yet there are possibilities that something tending in this direction might be accomplished through

arrangement with some engineering publishing companies, for example, with the *Engineering News,* with which the Society has an arrangement for its publications. Papers on historical subjects connected with engineering might be encouraged for the annual meetings. He thought a long discussion of the subject at that time not desired and moved that the president appoint a committee of three to find out and report if there is anything that can be done in this direction.

PROFESSOR J. P. JACKSON.—It is all right to teach engineering history, where it can be done suitably; it is an important subject, which every engineering teacher teaches more or less. Probably there is not a single one who does not have some fair idea of the history of the professions. He wished further to say that the engineering men who are out in practical life seem to have a kind of instinctive notion that they not only know how to build bridges, and do their professional work, but they know how to teach the professional student, and the college professor who has made that his life work.

PRESIDENT WOODWARD.—The motion is that the president appoint a committee of three to consider and report if anything can be done in this direction. Is there a second?

PROFESSOR RAYMOND.—Seconded the motion, if for nothing else than out of respect for the work that Mr. Waddell had done in this matter, which he thought deserved that attention. The gist of all the discussion is that the history of engineering is a desirable thing. Whether there should be one or a dozen volumes is not clear; some think there should, and some do not.

It seems entirely desirable that such a committee at least consider the matter and report back to the Society the following year.

Motion carried unanimously.

The president appointed two members on that committee, at once, Professor Williston and Professor Raymond; subsequently he added Professor Merriman.

The president asked the pleasure of the Society in regard to papers which had not been read, but which had been prepared and were on hand.

It was carried unanimously that they be read by title and placed in the hands of the editorial committee.

ENGINEERING EDUCATION IN SOUTHERN STATE UNIVERSITIES.

BY WALTER H. DRANE,

Professor of Civil Engineering, University of Mississippi.

Educational systems, being the instruments of social and industrial advancement, are the outgrowth of the needs of society. They are, however, not only the instruments of progress, but themselves the creatures of that development which they foster and, in a measure, create. Their relation to the economic growth of a state, or nation, is thus seen to be a two-fold and an intimate one. They are at once the creators and the creatures of social and industrial development, and, because they are the creatures of progress, they must adapt themselves to the conditions and the needs of the age and nation in which they exist or they will become a useless public burden. Whatever may have been the idea of the older scholastic fraternity as to the independence and the exclusiveness of the world of learning, it is yet true, it must be true of American institutions, that they were created for the people and hence they ought to supply the people's greatest need. When they cease to keep abreast of the progress of the age and fail, in any measure to supply that need, they to that degree become stagnated and decay sets in. An antiquated institution of learning, teaching only those things and using those methods which met conditions one hundred years ago, can not supply the complex necessities of a

progressive society of to-day and an enterprising people will no more patronize it than they will buy flint-lock muskets or ride in stage coaches to New York.

The law of supply and demand operates in the educational as well as in the commercial world, and, while of course it is not maintained that educational institutions must truckle to popular favor, yet, in obedience to that law, they (state institutions at least) must meet the demands of social and industrial progress in their states or they will suffer. The evolutions and the revolutions of society require changes in educational systems to meet the demands of changed conditions, and, whether the learned fraternity desire it or not, those changes will ultimately take place. As well attempt to force free silver upon the American people as to try to coerce the tide of educational advancement into a channel apart from the industrial needs of the nation.

With this view of the function of our educational systems, and their relation to social and economic conditions, we propose to ask, and briefly to answer the following questions: "Is there an urgent need for engineering education in the Southern States to-day, and, if so, whence arose that need? Why should the necessity be more urgent now than heretofore, and why greater in the South than in the North?"

In order to answer these questions I shall briefly recall the history of the settlement in America of two great peoples, the Puritan and the Cavalier, for out of the differences in the conditions surrounding their advent here arose the differences in our two great educational systems, differences fully justified as late as

forty years ago, but without a reason for their existence to-day and now rapidly disappearing.

The Puritan fled from persecution and sought on the bleak and rocky coasts of New England, the freedom of religious thought and worship denied him at home. No hardship, however severe, could offer an effectual barrier to his progress. He was willing to dare and suffer anything to secure his coveted liberty, and with desperate courage, he forced an entrance into a wild and uninviting country and founded a government. But the severity of his persecution at home was hardly greater than his physical suffering here, for, while constantly fighting savages, he was forced to wrest a livelihood almost literally from the rocks. Grim necessity thus imposed manual labor upon all, dignitaries of church and state, as well as upon the humblest citizen, and physical labor thus acquired a dignity, which became the keynote of his civilization and institutions. It was not socially degrading for him to work, because labor was honorable in all. He founded schools and an educational system grew up to meet the needs of his civilization. His schools sought to train in the practical arts, as well as to teach theory. They were not mental gymnasiums merely, but manual workshops, training the hand, as well as the mind; seeking to equip as well as to develop, and preparing young manhood to live by its own effort, not by the labor of others.

From this primitive educational system has descended the great northern system of to-day, and it was out of this necessity for manual labor in all, that grew the scientific spirit in the northern educational world. Forced to earn his living by his own effort,

the Yankee inventive genius was spurred on to scientific investigation in order to lighten the burden of his own labor. So we hear the northern schools of to-day boast of their laboratory facilities, and their keynote is practical training, as well as mental culture. They are giant factories supplying their products in trained talent to the industries of their states and promoting their material development. The effect of two centuries of this sort of education is apparent in the tremendous industrial and financial supremacy of the North to-day, and this supremacy the Yankee has won by superior skill, and not by political trickery, as some believe. Of course, now that they possess the wealth, the northern people are able to support better schools, but this relation of dependence of the one upon the other was originally reversed; it is not that the North has better schools, because it has more wealth, but it has more developed wealth, because it has more practical schools and has had them for two hundred years. It was a just appreciation of the truth that "wealth comes, not by legislation, but by labor," that placed the northern man in the lead, and he is holding the lead through the superiority of his school systems in their facilities for practical training.

We now turn to consider the conditions surrounding the early development of school systems at the South. It is like passing from the scenes of labor to the halls of state and the courts of kings, for, with the smiles of royalty upon him, equipped with every necessity for founding rich colonies, in his possession grants to immense tracts of land, the proud Cavalier landed in America upon a part most favored by climate and

natural resources. He found himself the lord of an immense territory, stretching hundreds of miles along the coast of the Carolinas and Virginia and further west than he dared to penetrate. Savages opposed his landing, but, backed by the guns of a mighty king, he drove them back with ease and founded colonies under the royal favor. As no danger threatened and it was easy to grow rich alone, there was no need to band together for protection, so the population soon became widely scattered. The towns and cities were necessarily small, being only central supply stations for the large plantations. Slavery was early introduced from the North, where it was found unprofitable, and, with its advent, began that petty feudal system which remained in power until 1865 and which, for two hundred years, stagnated industry in the South. Manual labor was regarded as degrading and fit only for slaves. The only calling becoming a gentleman was a profession or politics, and in these—in administering governmental affairs, in gaming and the chase—the blue blood and intelligence of the land spent its energies. Upon ignorant slaves devolved the task of creating all the material wealth and developing the country.

Schools were founded and an educational system grew up to meet the needs of this civilization. The school-room was a gymnasium for developing the powers of the mind and fitting for intellectual combat. It polished the country gentleman, preparing him for the rule of the vast estate he was to inherit, making of him always a political, but never an industrial leader. Philosophy, the classics, history, government,

theology, law, oratory, and medicine: these were the subjects mainly stressed and scientific training was neglected, because there was little need for it. Laboratories were sort of curiosity shops for the performance of idle experiments, and the scientific principles there learned were regarded as a part of the general culture of a gentleman of information, not as an equipment for life-work. There was no need to teach or to study engineering, for little engineering work was done and most of that by negroes, whatever required a high degree of skill being performed by northerners.

This system of education was efficient and all-sufficient for the needs of such a civilization. A school of engineering could not have succeeded in the South then, because there was no need for it, and it would not have been patronized. If a southern gentleman had equipped himself as an engineer and attempted to practice his profession in the South, he would have been forced to sacrifice his social standing to some extent, for engineering was not regarded as one of the learned professions.

But such a civilization, based upon slavery and reliant upon ignorance for its material support, could not stand. After all, the real cause of the abolition of slavery was an economic more than a moral one, for the result of the Civil War was inevitable by some means, if that war had never occurred. It was but the enforcement of what has always been and will always be the universal economic law, "In the sweat of thine own brow shalt thou eat bread," and conditions will adjust themselves in accordance with that law, even at the cost of a revolution. Woe unto the man or nation who attempts to disobey it!

Thus slavery was abolished and by its abolition the very basis of the old form of society was swept away. Southern people were suddenly placed upon the same footing with their northern brethren and were forced to meet new conditions for which they were unprepared. An industrial revolution then was set in progress and a development begun which is hardly yet under full headway, though it has reached proportions of which a slave-owning people little dreamed. Southern cities have grown to colossal proportions, industries have been developed which had not begun forty years ago, and on all sides there has arisen a need for skill unknown in the days of slavery. Mines are being worked, railroads and factories built, electrical plants by the thousand installed, even in small villages and towns, and the South's almost unlimited supply of water is being harnessed to do the work of millions. The shackles of slavery struck from his limbs, the giant of industry awoke from his sleep of two hundred years at the South and began a new life of activity and freedom.

But the southern people, though eloquent in speech and learned in the arts, were, as a whole, unskilled as engineers and thus unable to compete with their northern brethren in supplying this new call for trained talent. The bravery of the southern man in laying aside his old pride, in entering unaccustomed fields of labor, and in meeting new conditions, was by no means exceeded by his valor on the field of battle, but the odds have been against him and slowly the talent of the northern man, trained for two hundred years, has been gaining ground and getting possession of southern in-

dustries. Their engineering skill is winning a victory more lasting and far-reaching than was consummated by arms at Appomattox.

With the abolition of slavery, a revolution other than a social one was begun, and, because slow in its progress, Southern people did not realize it. The necessity for a new sort of education arose, for the educational system of the old régime could not supply the needs of this rapid industrial growth. It must face about and adapt itself to the changed conditions. But the change was slow, and it was only after fifteen or twenty years that southern educators began to realize its necessity and that a revolution was really in progress. Even to-day its advance is contested by some, who cling with superstitious reverence to the classic forms, and the claims of engineering education for a place in the university curriculum is still, in some quarters, regarded with suspicion. This reverence for the classical education has a stronger hold in the south than in the north and southern educators have been slower to accord to engineering a place of dignity in their university curricula. Schools of law, medicine, theology, and pedagogy are still given the prominence in their catalogues and engineering schools have forged their way to the front with difficulty, and only after a long fight, if at all. Engineering, therefore, is still regarded popularly as a trade, instead of a learned profession, and is denied the dignity accorded to the law and the medical professions. The result has been inevitable. An average of about 70 per cent. of the graduates of these state institutions usually enter the professions of law, medicine or teaching and badly

overcrowd them. Up to 1890, the curricula of the majority of these institutions were so framed as almost to force young men into one of these professions, for they offered no preparation for anything else. Those who were independent enough to enter the profession of engineering were forced to go to northern schools and the poverty of the South following the war rendered that an exceedingly small number. As late as 1898 there was no school inside the entire state of Missippi where a young man could study the simplest principles of engineering, much less fit himself for practical work in a laboratory, and some other states have been almost as slow in providing these facilities. The economic result of this in the South need hardly be mentioned for it is sufficiently evident, by contrast, in the tremendous industrial supremacy of the North to-day.

But enough has been said to attest the pressing need for a larger development of engineering education in the southern state universities. These institutions are the heads of the educational systems of their states, and, if this field is to be developed in the South, the work must begin there.

It has, however, been begun already, and we now wish to answer briefly another question: "What are Southern State Universities doing towards Engineering Education?"

To obtain the information necessary to do this, a list of questions was mailed to the engineering schools of the southern state universities asking for a full account of the status of the work, its extent and advancement, and it was the intention from the information thus gained, to make a full and detailed report of the

work in each school. But the responses were very few and not enough data has been collected to compile such a report. These questions were sent to the universities of Virginia, North Carolina, South Carolina, Georgia, Alabama, Louisiana, Texas, Arkansas, Tennessee, and Kentucky. Responses came only from Virginia, Texas, and North Carolina, and these three, together with Mississippi, are the only universities of which we can speak fully. As this will not afford a sufficient basis for a just report of engineering education in southern state universities as a whole, such as we must give in accordance with our subject, we can only offer, in its stead, information, in a general way, as gained from the catalogues of those universities which failed to respond, and from the reports from the above four states. From Kentucky no information has been received, and that university will not be included. Florida was not included in the above list, because that state has no regular state university. It has several state schools of advanced grade and manual training schools are being developed, but these again were without our province and were omitted.

There is one fact to which we must call attention, too, before going further, viz., that we shall confine our attention to the state universities. This of course will not be a full report, by any means, of engineering education in the southern states, as announced for the subject of this paper upon the program. In some of the states, viz., North Carolina, South Carolina, Alabama, and Mississippi, there have been for many years maintained agricultural and mechanical colleges, which have offered opportunities for practical training and, in one

or two instances, have long fostered engineering courses of advanced grade, but in most cases their engineering instruction is more on the order of manual training. In these states, however, because of the existence of these state schools, the universities have been slow to introduce engineering courses of advanced grade into their curriculums, largely because the legislatures refused to make appropriations therefor in addition to what was given for the agricultural schools. No report will be made of these schools and it was to avoid doing an injustice to the states maintaining them separately that the above fact has been mentioned.

In most of the remaining states, the agricultural and mechanical colleges are combined with the universities and it is in these states that the most advanced engineering work is being done. This is the case in Texas, Arkansas, Louisiana, Tennessee, and Georgia. It is but a proof of what the author of this paper would advocate that the engineering work be done at the state universities, where more thorough theoretical courses are offered as a basis therefor. He would not cast discredit, however, upon manual training, for he realizes the importance of this phase of industrial education in the state's development, but he does not believe that young men should be turned out as engineers, with the guarantee of the state behind them, until they have received that broad and thorough scientific education without which success, in its highest sense, as an engineer, is impossible; and this thorough mental training is afforded in the university courses of the states more than in the agricultural and mechanical colleges, where attention is largely directed to manual training.

The first thing noticeable in regard to engineering work in these universities is that, while civil and electrical engineering have been receiving attention for the past ten or fifteen years, mechanical engineering has not been so largely developed. The author accounts for this partly by the fact that machinery, necessary for giving such instruction, is expensive and the states have not been thus far able to install sufficient plants, but it may also be explained by the fact that the largest demand in the South now is for civil and electrical engineers. Many universities, however, have enstalled quite extensive plants and have for several years been offering courses in machine design, shop and metal work, etc.; among these may be signally mentioned Louisiana, Texas, and Georgia.

The average per cent. of the entire student bodies taking engineering in these universities is twelve, which compares favorably with the demand for engineering evidenced in many of the larger northern universities. These courses have proven popular, as soon as introduced, and attendance from the start, in nearly all instances, has been flattering. In the University of Mississippi, where courses in engineering have been offered for only the past three years, the attendance upon them is about eleven per cent. of the entire student body and is still on the increase. All universities are finding growing demands for all work they can offer. This demand, judging from reported enrollment, seems by far the largest for civil engineering. We account for this by the fact that, while a large amount of electrical work is being done in the South, the profession of electrical engineering is not popularly as well known

as that of civil engineering, because it is not so old. Even in the North, it has developed only within the last twenty or thirty years.

The requirements for admission to engineering courses in southern state universities is about the same as in northern colleges. In mathematics the requirements are: Arithmetic, algebra to quadratics, and the first three books of plane geometry. In English: A thorough knowledge of English grammar and some acquaintance with literature. In science the requirements are variable, most of the universities giving no credit at all for the work done in the lower schools. In the foreign languages, many of the universities, signally the University of Texas, still maintain admission requirements in at least one of the classics, though none, so far as we have found, require it for graduation. Many of the universities also have admission requirements in one modern language, though the majority have none.

The engineering courses compare in extent and advancement favorably with those of northern universities, at least as far as theory is concerned. They are, in general, about as follows: From two to four years of English; one modern language, from one to three years; physics, two years; chemistry, two years; mathematics, from three to four years; geology, one year; biology, one year; drawing, from two to three years; surveying, from one to two years; and then the various subjects in engineering proper, as bridge and roof design, masonry, road construction, electrical and hydraulic engineering, etc., from one to two years each. There is nothing lacking in the work as far as

theory is concerned. The universities all have from two or three to eight or ten instructors in engineering and, in this regard, are fully equipped to meet the demands made upon them. It is in their facilities for laboratory work, and the time allotted to it in their schedules, that they compare most unfavorably with northern schools. But it must be remembered, in the former comparison, that engineering is yet in its infancy in these schools and that whatever growth has been attained, has taken place within the last ten years, in many instances within the last two or three. While educators are rapidly realizing the necessity for thorough and extensive laboratory instruction in engineering, it has been no easy matter to convince the state legislatures, upon which these universities mainly depend for support, that these things are necessary, and, in consequence, appropriations for their supply are but slowly forthcoming, if at all. The public mind must be educated up to their necessity before any extensive growth can be attained. A campaign is on, with this purpose, in nearly every southern state, and the increasing liberality, in this direction, of the legislatures of the past five years attests its growing success.

It was our purpose to make a report of the value of equipments in all the southern state universities, but the lack of sufficient information forbids our doing so. Instead, we can give only rough estimates, as a whole, gleaned from the few reports sent in and from the meager accounts in catalogues.

The average value of equipments for all work is about $5,000, ranging from a few hundred dollars in North Carolina, South Carolina and Mississippi, to

eight or ten thousand in Texas, Louisiana, Georgia, and Tennessee. The largest part of this equipment is, in nearly every case, for drawing and surveying, very few of the universities having provided any extensive electrical or testing laboratories. Texas is a signal exception to this in regard to testing laboratories for they report a laboratory valued at $3,000, and equipped with modern machines. They are lacking however, in electrical equipments, though an extensive engineering building is soon to be erected there and no doubt these deficiencies will be fully remedied. The University of Mississippi is now erecting an engineering building, and at its completion, a full line of equipments for electricity, surveying, and drawing will be installed. In all the southern universities, improvements of this character are going on and will be continued, as funds are supplied by the legislatures.

But the second feature, in which improvement needs to be made in southern engineering colleges, is in the time allowed in schedules for practical work in the laboratories. This ranges, from "watching the instructor perform experiments" for an hour or two, to four or five hours' work per week. It is here that the battle is on between the languages and philosophies, on the one hand, and the practical sciences on the other. The advocates of the former colleges are disposed to crowd too much of their subjects upon the engineering student, consuming the larger part of his time in the recitation-room and leaving little for laboratory work. The schedules of most southern universities are thus crowded with too many recitation periods, many educators denying the claims

of the laboratory period to being as beneficial in developing the mental powers as well as the physical. This is but a manifestation of the spirit in the South to cling to the old form of education, which was referred to at the beginning of this paper, and which it will take time to overcome. It is this defect that most needs remedying and it would be interest-to compile a report of some of the southern schedules as evidence of that fact, but space forbids.

In closing, the writer would ask the coöperation of the members of this Society in promoting the development of engineering education in southern state universities. The resources of the South are, as yet, largely undeveloped, and, if she is to reap the reward of the inexhaustible wealth with which God has endowed her, it must come through the education of her people along engineering lines. Develop a state's mines of talent and her mines of wealth will be developed. This can best be done by fostering colleges of engineering in the heads of the state educational system—the state universities.

SOME CHARACTERISTICS OF TECHNICAL EDUCATION IN AUSTRALIA.

BY S. HENRY BARRACLOUGH,

Acting Professor of Engineering, Russell School of Engineering, University of Sydney.

1. In responding to the request from the secretary for notes on this subject I should state at the outset that owing to an unavoidable delay in the receipt of his letter, only three weeks of the busiest term of the year remained for the compilation of the paper, which must therefore be somewhat fragmentary, and perhaps may not contain information as detailed and specific as would be desired.

2. The time, however, on one or two grounds, is not inopportune for outlining the progress of technical education in this part of the world.

The Federation of the Australian States—notwithstanding a considerable amount of disappointment and dissatisfaction natural to the difficult period of inception—may reasonably be regarded as marking an epoch in the development of the country and a period from which great changes may be expected to date.

In the next place, the past year has witnessed the celebrations in connection with the jubilee of the University of Sydney—the oldest university in Australia, as well as in the British Empire outside Great Britain—a time when the aims and ideals, as well as the methods and achievements of such institutions, come naturally under review.

Finally, the question of education, and in particular of technical education, is now being actively canvassed in Australia. There has of late been a most distinct advance in the growth of public opinion in relation to our national education. It is coming to be more popularly recognized that only by a thorough and genuine system of education can Australia hope to gain and hold its place. A strong desire is evinced for the speedy establishment of a chair of education in the University of Sydney. The interest of the government in the whole matter is evidenced by the fact that an educational commission has just returned from a tour of enquiry in Europe and America, and their report is expected at an early date. It is believed that when their recommendations come to hand, strong efforts will be made to thoroughly reorganize the educational system.

Most of the following remarks will refer to Australia and Tasmania only, and not to New Zealand except incidentally. New Zealand remains, probably permanently and from its point of view possibly very wisely, outside the commonwealth. Separated from the continent by, at the shortest, a three or four days' ocean journey, and possessing great resources of its own, and interests sometimes opposed to those of Australia, there seemed little to gain, and perhaps much to lose, by casting in its lot with the other Australasian states.

3. Certain preliminary considerations are to be noted for the better understanding of the conditions affecting technical education in this quarter of the globe.

Australia, with an area closely approximating to that of the United States, is, like America, a land of mag-

nificent distances, but is unfortunately unlike America in the matter of population, there being just short of four millions of people on the whole continent, and these are mainly located in the districts bordering on the coast. More marked still under such circumstances is the concentration of the people in a few large cities, Sydney and Melbourne, for instance, between them accounting for about a quarter of the entire population. In New Zealand alone has this difficulty of centralization been avoided.

Prior to their federation on the first day of this century the different states were largely in a condition of mutual isolation, with separate parliaments and governments, opposing tariffs, with very different and at times strongly antagonistic policies, with widely differing railway gauges—in short they were more or less foreign countries constituting a heterogeneous whole, itself comparatively isolated from other centers of thought and activity. Under such circumstances it would be natural to expect that the educational system of the community, even when most sincere and enthusiastic, should be irregular and promiscuous.

Next it is worthy of note that Australia as a whole enjoys, or perhaps better, shares, a degree of state socialism almost without parallel.

There is a distinct and growing tendency towards concentrating all responsibility in the government and removing it from individuals. Private enterprise is largely discouraged, especially in connection with all public services, such as railroads, street cars, telegraphs, telephones, and water supply. For a considerable time past strong efforts have been made towards

the establishment of state-owned iron and steel works in Australia. Arbitrary conditions as to price and hours of labor are imposed in all government contracts, and where the state is called upon to carry out so much work the conditions of these contracts often control the situation. Courts of arbitration now exist in some states, and these, although serving a confessedly useful purpose in preventing strikes and other industrial conflicts, yet possess such absolute powers in respect of wages and conditions of work as to seriously hamper individual enterprise. The benefits of such a system cannot of course be had without the opposing evils.

Speaking generally, there has been but small industrial and manufacturing development in Australia. The power developed in the Brooklyn Power Station would suffice to run all the manufactories and industries in the commonwealth.

To refer again to iron and steel works, which are universally recognized as an index of industrial progress, on several occasions the representatives of syndicates desirous of establishing large iron and steel works here have visited the country, but have always been discouraged by the local conditions (particularly those of labor and wages) and have withdrawn. It remains to be seen whether the abolition of interstate tariffs and the imposition of the present federal tariff will materially improve the situation.

The industrial position must, of course, react on the educational position. It is useless to train and educate men to be leaders of industry if no capital is available for their direction and no skilled workmen to carry out their plans.

As an illustration which has a direct bearing on the question at issue—in New South Wales the Department of Public Works controls practically all the civil engineering in the state. The consulting civil engineer, as understood in America, is almost unknown in Australia. This, of course, is a matter of extreme moment to institutions which train civil engineers, since almost the only course open to graduates in that subject is to enter the Government Department. An apparently growing disinclination to do this has of late years caused the civil engineering side in the University of Sydney to be practically abandoned by students. In order to remedy this state of affairs and to provide engineering cadets for the public service, fresh regulations have recently been drawn up offering considerable inducements to graduates in civil engineering of the university to enter the Works Department. There is no experience yet to show whether the inducements offered are sufficient, but the indications are favorable.

There is in New South Wales, and generally in Australia, no system of local government, except as regards the municipal direction of townships, and the scope of municipalities is extremely limited as far as carrying out any engineering work in concerned. Even in a large city like Sydney the municipal council has extraordinarily little power with regard to public works within its own boundaries.

The undue concentration of responsibility for public works of all kinds in one department under the control of a minister of the Crown, although offering some obvious advantages, yet must inevitably lead to alternations of periods of what has been euphemistically

termed "a spirited public works policy" and periods of more or less severe retrenchment.

If these communistic ideals more and more are to hold sway in the community, nothing but the development of the highest intelligence of the people by a sound and thorough system of true education can keep the country from disaster.

4. It is difficult to describe in general terms and few words the scheme of education which obtains in Australia, chiefly because the educational plan has not been systematically developed. The same remark would probably apply, if not with equal force, at least with considerable pertinence, to Great Britain and the British Empire generally. It is not necessary in the present juncture to consider whether it is a characteristic common to the English-speaking peoples.

It would be generally admitted that it is the temperament of the British people as a whole rather to distrust elaborately organized and finely differentiated schemes, such as are natural to the German mind. That a scheme of national education requires to be based on correct scientific and philosophic principles is apparently not an idea that comes naturally to the Britisher. He believes himself capable of devising and organizing a scheme that will be sufficiently satisfactory. This characteristic has been over-emphasized in Australia. The people are peculiarly self-reliant and possibly to a considerable degree, self-satisfied. Great enthusiasm has from time to time been displayed in educational matters, but much of it has been largely misdirected.

The chief defect of the system is its lack of coördination, resulting in low efficiency of operation. The ma-

terial equipment in the state educational scheme has been distinctly in advance of the perception of how to make efficient use of it. Much more energy has been devoted to equipping schools and institutions than to the more difficult and essential task of providing them with properly trained teachers.

To have once clearly recognized a defect is a long step towards its removal, and there is every reason to believe that the task of reorganizing the entire state system of general and technical education on the most modern lines is about to be undertaken.

5. The following statement will show in a brief and precise manner the geographical distribution of nearly all the institutions which offer courses of instruction in the various branches of engineering. It excludes colleges devoted entirely to agriculture and also privately owned institutions which conduct classes in mechanical drawing and allied subjects. Nor is any attempt made to record the classes in technical subjects held under the auspices of what are known here as "schools of arts."

New South Wales.—The University of Sydney (with well-equipped engineering school). The (state) technical college at Sydney, with branches at Bathurst, Goulburn, Newcastle, Maitland, Broken Hill, and Albury, and local classes in various suburbs.

Victoria.—The Melbourne University (with well-equipped engineering school). The Working Men's College at Melbourne. The School of Mines at Ballarat; and numerous other institutions of a similar nature but on a smaller scale, such as at Bendigo and Bairnsdale.

South Australia.—The Adelaide University (with engineering school). The School of Mines and Industry at Adelaide. The School of Design at Adelaide.

Queensland.—No university. The Technical College at Brisbane. The School of Mines at Charters Towers.

West Australia.—No university. A technical school at Perth.

Tasmania.—The University of Tasmania (recently started and at present on a limited scale).

New Zealand.—The University of New Zealand (a governing and examining body only) with constituent colleges at Auckland, Otago, Christchurch,* and Wellington.

6. These institutions may be satisfactorily classified under two heads:

(*a*) Universities and colleges of academic grade, with fully equipped engineering schools which for purposes of comparison we may put in the same category as regards general aim and method, although on a smaller scale, with say Sibley College and the engineering division of Harvard University—to quote some of those with which I am most familiar.

(*b*) What are commonly called here and in England "technical colleges," which vary enormously in character, but which, in their highest grade of work, aim at developing into institutions approximately of the type of the Massachusetts Institute of Technology, and in the lower grades are merely of the order of manual training or trades schools.

* The Engineering School of the university is at Christchurch; the School of Mines is at Otago.

To illustrate these two classes, a short description will be given of the University of Sydney and the Sydney Technical College, the two largest educational institutions in New South Wales. The former is the oldest, as well as the largest, of the Australian universities and may be fairly regarded as offering a typical example of the best university instruction obtainable in Australia, while the latter is not only on a very much bigger scale than anything else of the kind in the country, but illustrates in a somewhat marked degree many of the advantages and some of the defects of such institutions.

7. A few summarized particulars of the expenditure by the state of New South Wales (the mother state of the commonwealth) on education will indicate that a distinct effort has been made to meet the responsibilities of the situation. Attendance at school is compulsory for all children between the ages of six and fourteen. A fee of threepence (six cents) per week is charged, exemption from payment, however, being allowed wherever necessary. The work is carried on by the Department of Public Instruction, presided over by a member of the State Cabinet—the Minister for Public Instruction.

The various amounts are given in round figures, and represent about the average annual payments for the last two years.

NEW SOUTH WALES.

Area	310,000 sq. miles.
Population (total)	1,410,000
Population (Sydney and suburbs)	503,000
Annual expenditure for state schools	$3,750,000

Annual expenditure for Sydney Technical College and branches............	$125,000
Annual expenditure for Sydney University..........................	$75,000

These amounts are derived directly from state funds, and do not include any private benefactions, of which in the case of the university there are a considerable number. There are numerous other minor directions of state expenditure for educational purposes which bring the total sum annually expended to considerably over four million dollars. The sum spent is large, although not yet large enough—had it been expended according to a wise and well-thought-out scheme the educational position would have been far higher than it is. But the most severe critic of the system will admit that something has been achieved and that the average of intelligence and information in the community is high, even if the ideals of true education have been at times somewhat lost sight of.

8. The University of Sydney was founded in 1852. It stands in its own park of 134 acres on a hill overlooking the city within half a mile of the central railway station. The various buildings have been erected by and are maintained at the expense of the state. The institution is governed by a senate consisting of sixteen members elected (for life) by the vote of the alumni, and four *ex officio* members (usually the deans of the four faculties). The state has no direct voice in the management.

Affiliated with the University are residential colleges belonging to the various religious denominations, as well as a non-sectarian college for women. The ma-

jority of students live, however, in private houses. The university is coeducational; of the 746 students attending lectures this year, 639 are men and 107 women.

The lectures of the arts course (only) are repeated in the evenings (between the hours of six and ten each night) for the benefit of those who cannot attend in the daytime. The state makes a special grant of $10,000 a year for this purpose.

The university has received various sums in the way of private benefactions, the two most important being the Challis Fund of $1,250,000 for the general purposes of the university (includes the chair of engineering) and the P. N. Russell Fund of $250,000 for the engineering school. It, however, urgently requires more funds.

Its annual income is here summarized:

From the state	$75,000
From private benefactions	90,000
From students' fees	60,000
	$225,000

The amount awarded each year in scholarships, prizes and bursaries (including three travelling fellowships) is about $11,000—a large proportion of which is available for competition by science and engineering students.

The teaching staff at the present time consists of: 15 professors in charge of departments or subjects; 36 "independent lecturers" in charge of subjects (corresponding about to "associate professors"); 8 assistant lecturers (corresponding about to "assistant profess-

ors"); 6 senior demonstrators (in charge of laboratory instruction), and 7 junior demonstrators (to assist in laboratory instruction).

There is also a fair staff of operators and laboratory assistants.

The average salaries paid are approximately as follows: For a professorship $5,000; for an independent lecturership from $750 to $2,500, depending on the number of lectures; for an assistant lecturership $1,750; for a senior demonstratorship $1,750; for a junior demonstratorship from $500.

The method of nominating particular individuals to professorships is quite unknown in Australia. Instead, advertisements are inserted in leading European, American, and Australian newspapers stating that applications with testimonials are to be sent to a committee in London. This committee, after considering the applications, selects usually three names and sends them with a recommendation to the university authorities in Sydney. Professors are appointed for life—*quamdiu se bene gesserint.*

There are four faculties in the university, arts, law, medicine (including dentistry), and science (including engineering).

The engineering department was established in 1884 under the able direction of Professor W. H. Warren, who still occupies the senior position on its staff. It is now known as the P. N. Russell School of Engineering, in accordance with the terms of a gift of $250,000 by Mr. P. N. Russell (formerly a resident of Sydney, but now living in London) for the purpose of endowing the school. Mr. Russell was for many years a dis-

tinguished manufacturer in Sydney, and did great service in the earlier days in developing some of the industries of the state. He, many years ago, however, abandoned his works and went to reside in England.

Before entering the Engineering School a student must either have passed through the first year of the arts course, or must pass a special "engineering entrance examination" of a distinctly higher grade than the ordinary matriculation examination.

There are three courses in engineering: (*a*) Civil, (*b*) mining, and (*c*) mechanical and electrical engineering. Each of the first two may be completed in three years, and the last in four years, but a movement is now being made towards a uniform four years' course in the engineering department, or five years, including the first year of the arts course. A considerable number of students have adopted the very good plan of first going through the first two years in engineering, then taking an extra year in which to complete their science course, finally returning to the engineering school to finish their professional course.

There is as yet no complete course in architecture, but students in civil engineering are required to attend courses of lectures on building construction and the history of architecture.

The total enrolment of engineering students for the last two years was 106 and 103 respectively. A falling off is expected this year as a result of the extremely dull times and a correspondingly lessened demand for graduates' servives.

For several years after the school was started the numbers were limited and all students took the civil

engineering course; some of the graduates now hold important positions in the Department of Public Works. Then, with the inauguration of a complete and efficient mining course nearly all students obtained their degree in that subject, and for the first few years small difficulty was experienced in obtaining lucrative appointments, but the supply of graduates overtook the demand, and there has for some time past been a falling off in the number of mining students, while the more recently inaugurated mechanical and electrical engineering course seems now specially attractive. Possibly in this direction also the demand for trained men will in a few years not come up to the supply.

The degree conferred at the end of the course is that of "B.E." (Bachelor of Engineering) in civil engineering, mining, or mechanical and electrical engineering as the case may be. Separate degrees are not given in mechanical and in electrical engineering, it having been decided that these two subjects must necessarily be studied together.

A second degree of "M.E." (Master of Engineering) may be obtained (on passing the requisite examinations) by those graduates who passed with honors at their first degree examination, and who subsequently have had three years' professional experience, of which one at least must be practice in the field, or its equivalent.

The following are the subjects in the respective years for the three courses:

FIRST YEAR.

Civil.	*Mining.*	*Mechanical and Electrical.*
(The same.)	Mathematics. Descriptive geometry. Applied Mechanics (with laboratory practice). Chemistry (with laboratory practice). Physics (with laboratory practice). Mechanical drawing.	(The same.)

SECOND YEAR.

Mathematics. Surveying. Civil engineering. Physics. Geology. Applied mechanics. Heat engines. Mechanical drawing.	Surveying. Engineering construction. Physics. Geology. Mineralogy. Chemistry. Applied mechanics. Heat engines. Mechanical drawing.	Mathematics. Applied mechanics. Physics. Chemistry. Heat engines. Mechanical drawing. Mechanical workshop.

THIRD YEAR.

Mathematics. Materials and structures. Civil engineering.	Materials and structures. Metallurgy. Assaying.	Mathematics. Surveying. Mechanical engineering.

Architecture.	Mining.	Electrical engineering.
Surveying.	Drawing and design.	Physics.
Drawing and design.		Mechanical workshop.
		Design of prime movers.

FOURTH YEAR.

		Electrical engineering.
		Transmission of power.
		Railway engineering.
		Design of generators and motors.
		Electrical engineering laboratory.

In connection with nearly all the above subjects students are required to do a large amount of laboratory work.

The systematic work shop instruction is given at the work shops of the Sydney Technical College, which are well equipped for the purpose, this course making it unnecessary to duplicate a great many machine tools and to increase the shop staff at the university. The machine shop of the university is mainly devoted to the construction and repair of machinery and apparatus required for purposes of instruction and investigation.

The work of the department is carried on in two or three fairly convenient, although now rather crowded buildings.

The engineering laboratory instruction may be divided into four sections: (*a*) General mechanical labo-

ratory work to illustrate the applied mechanics lectures, (*b*) the testing of materials, (*c*) heat engine testing, (*d*) electrical testing. Of these (*a*), (*c*), and (*d*) are fairly developed and usefully equipped, but (*b*), the testing of materials, is the only course which may be regarded as practically complete. The school is equipped with nearly all modern appliances for the testing of materials, of German, English, and American make. Many thousands of tests have been carried out, some for commercial purposes (iron, steel, cement, timber, etc., for government and other contracts) and others for purposes of scientific investigation. Probably one of the greatest services rendered by the engineering school to the community has been in connection with this department. As a particular illustration reference might be made to the elaborate investigation of the strength of Australian hardwoods. Capable students are encouraged to take up original investigation in the laboratory. The graduate department is, however, a very small one, few men remaining at the university after their graduation.

In policy there is very little to note that would be of special interest or novelty to members of the Society. Almost the only controversial question which has arisen is as to whether electrical engineering should properly be taught by the department of physics or of engineering. The issue was somewhat warmly supported on both sides for a considerable time, and a great quantity of information was collected from different parts of the world on the subject. It has now finally been decided that all professional engineering instruction, whether by lecture or experiment, shall be delivered in the engineering school.

9. *The Sydney Technical College.*—So far as appears to be known the first regular instruction in New South Wales in any technical subject was given at the Mechanics School of Arts in Sydney in 1865, when a class in mechanical drawing was inaugurated, with Mr. Norman Selfe as instructor. In 1873 it was resolved to establish a working men's college in connection with this school of arts, and for some years following, technical instruction was developed to a certain extent under this institution. In 1883 responsibility for technical and industrial education was given to a committee known as the board for technical education, and this committee largely developed the subject until in 1889 the State Department of Public Instruction assumed the control of the work which is now known as the Technical Education Branch of that department.

The work of this branch embraces matters relating to: (I.) The Sydney Technical College, (II.) the suburban technical classes, (III.) the country technical colleges and classes, and (IV.) certain classes connected with high schools and public schools.

Hereunder is a comparative statement* of statistics for the whole branch, for the years 1901 and 1902:

	No. of Classes.		No. of Individuals.		No. of Enrolments.		Weekly Average Attendance.		No. of Lecturers and Teachers.	
	1901	1902	1901.	1902.	1901.	1902.	1901.	1902.	1901.	1902.
I. Sydney.	83	96	3,940	3,819	5,812	5,903	4,045	4,307	65	68
II. Suburbs.	39	41	400	582	677	694	420	443	10	14
III. Country.	147	208	2,918	3,185	3,424	4,065	1,893	2,344	49	71
IV. School classes.	62	86	2,009	2,819	2,354	3,018	1,363	1,748	9	19
Totals.	331	431	9,267	10,405	12,267	13,680	7,721	8,842	133	172

* Quoted from the report for 1902 of the Superintendent of Technical Education, Mr. D. J. Cooper, M.A.

The variation in the total number of enrolments for the last ten years is indicated in the following table. The year 1894 was that immediately succeeding the period of financial crisis and great commercial depression in Australia.

	1892.	1894.	1901.	1902.
Sydney Technical College...	3,858	2,956	5,812	5,905
Suburban classes.........	1,193	508	677	694
Country classes.......	3,709	2,500	3,424	4,156
School classes..................	1,329	579	2,354	2,927
Totals.......................	10,089	6,543	12,267	13,682

In respect to ages the students for 1902 may be grouped as follows:

	Under 14 Years.	14-15 Years.	16-20 Years.	21-25 Years.	26-30 Years.	31-35 Years.	36-45 Years.	Over 46 Years.	Total.
Males........	51	371	1,565	380	149	131	19	-	2,666
Females.....	6	103	467	283	152	125	12	5	1,153
Totals........	57	474	2,032	663	301	256	31	5	3,819

This table shows that 53 per cent. of the individual students of the college are from sixteen to twenty years of age, and that 97 per cent. of them are from fourteen to thirty-five years of age.

As has already been pointed out the state spends annually about $125,000 on the technical education branch. There have been no private benefactions, and the return from the students' fees is small, the fees being little more than nominal—namely, in the majority of cases one dollar per term for students under twenty-one and two dollars for students over that age.

The range of subjects taught is extremely wide, including such as agriculture, wool classing, geology,

chemistry, mechanical and electrical engineering, physics, mathematics, sanitation, architecture, printing, plumbing, art, decorative art, domestic economy, lithography, bookkeeping, shorthand, mine surveying, coal mining, and even dressmaking and millinery.

The very large number of enrolments in the various subjects is sufficient evidence that the college serves a useful purpose and meets a popular demand for instruction. The classes are conducted chiefly in the evening, and students have in the past been allowed to select almost any courses they pleased, there being no entrance examination and no age limit.

Systematic "diploma" courses of two or three years' duration are arranged in the different departments of the college, but comparatively few students complete them, and there is no doubt that in the past a great waste of energy has gone on by students following individual courses of instruction for which they were not prepared and for which they had no use.

It is not to be wondered at that under these circumstances the college quickly became overcrowded. There were at one time (1901 session) no less than 2,435 students on the lists waiting for admission to the Sydney College for whom there was absolutely no room. The situation has lately been greatly improved by the action of the present superintendent in limiting the minimum age of admission to fourteen years and in providing that no student should be admitted to a class who had not had in a reasonable degree the necessary preliminary training. Further, applicants for admission to the more crowded classes (*e. g.*, fitting and turning, plumbing, mechanical drawing) are divided into

three sections: (*a*) Those for whom the instruction is necessary in connection with their daily work; (*b*) those for whom it is helpful but not necessary; (*c*) other persons; and precedence is given to those in section (*a*) and then to those in section (*b*).

The attendances at the annual examinations in December, 1902, were 4,931, or 83 per cent. of the total enrolments. Of this number 3,568 were successful, equivalent to 72 per cent. of the total attendances, or 60 per cent. of the total enrolments.

One of the most important steps taken this past year has been the inauguration of day classes for the systematical teaching of electrical and mechanical engineering, a regular three years' course being carried out. These courses will be intermediate between a trades course, and the full professional course followed at the university. The conditions of entrance are, that the candidate shall be sixteen years of age and be able to pass an examination in English, arithmetic (including the metric system), and algebra. Attendance for six hours a day, or thirty hours a week is required. The course covers three years, the first year being the same for both classes, namely mathematics; physics; chemistry; freehand, model, geometrical and mechanical drawing; and woodwork. For the second and third years most of the work will also be common to both classes and will include mathematics, chemistry, mechanical drawing, applied mechanics, fitting and turning, pattern making, blacksmithing (for mechanical engineers), and electrical engineering (for students of that class only).

It is hoped shortly to establish similar classes in architecture and sanitary engineering.

The general aim and policy of the Technical College, with its various branches throughout the state, has so far not been clearly defined either in relation to other educational institutions or to the industrial activities of the country.

One of the most useful adjuncts of the college is an extremely valuable technological museum, the collection of specimens which has now been got together being of great service to the industrial community. It would be impossible here to give details of the scope of the museum. As one illustration of its important collections may be mentioned the wool exhibit of over 7,000 specimens of representative raw wools and wools in all stages of manufacture, obtained not only from every part of Australia but also from almost every country in the world. A reference to the museum would be incomplete without particular mention of the laborious investigations which the curators, Messrs. Baker and Smith, have for several years past been carrying out on the botanical and chemical characteristics of the Australian eucalypts and their products. Apart from their high scientific value and interest these investigations are already beginning to have an important effect on the eucalyptus oil industry of Australia.

One other museum in the Technical College deserves mention. It was built especially to house a splendid example of an original James Watt steam engine (built 1784) with rotating fly-wheel driven by the sun-and-planet-wheels mechanism. The building also contains the first locomotive that ran in Australia, and a portion of the first pumping plant for the Sydney water supply.

10. Before closing these remarks it may be worth noting that in Australia particularly, with its largely undeveloped resources, technical educationalists have a twofold function to serve. Not only must they provide trained students to meet the present demands of the industrial situation, but they must estimate the probable direction of future developments and so plan the educational system as at once to foster and serve that development. There are in Australia certain definite industrial and engineering problems, such as the following, the solution of which will demand much skilled training and some of which at least have not yet been attempted very thoroughly. The field for technical instruction is evidently sufficiently wide.

1. Agricultural and pastoral industries (especially wheat, wool, and meat).

2. Water conservation and irrigation (now seen to be absolutely essential on a large scale).

3. Mining development.

4. Timber—the proper management and efficient use of the unequalled hardwood forests, which on the whole have hitherto been ruthlessly exploited.

5. Development of the manufacturing industries (now quite in their infancy).

Above all, from the point of view of our Society, the great problem of the country is the liberal and technical education of the people, so that the urgency of these tasks, amongst others, may be realized and the means provided for performing them.

11. In conclusion I desire to express my thanks to Mr. G. H. Knibbs, one of the educational commission-

ers, and to Mr. D. J. Cooper, M.A., for their kindness in affording me useful information, and further to the latter for the series of photographs of the Sydney Technical College accompanying this paper. To Professor Warren also I am indebted for most of the photographs of the University of Sydney.

REPORT OF THE COMMITTEE ON STATISTICS OF ENGINEERING EDUCATION.

BY WM. T. MAGRUDER, *Chairman.*

Your committee would respectfully report that since it submitted its last report (Vol. X., page 231), it has spent such time as was available in tabulating the statistics on the enrollments by colleges of the educational institutions of the United States having courses in engineering, and the enrollments by departments and classes in the different engineering colleges of the United States, for the year 1901–02, and which form Tables I. and II. of that report.

The committee now presents a graphical chart giving the number of students enrolled in 1901–02 in the different classes of certain of our engineering colleges, and also having lines representing the average decrease in numbers from class to class of all the engineering colleges reporting. These lines represent the algebraic sum of the losses by undergraduate mortality and by growth. Thus, an unusually large freshman class would make it appear that there had been a large number of men dropped from the preceding freshman class, whereas such may not have been the case.

Your committee is now engaged in tabulating the seventy odd different engineering degrees which have been conferred since 1824, in the ten subdivisions of the profession, and hopes to be able to present the tables as part of its next report. In this connection, the committee would ask that if any of the members have lists

of degrees which have been granted by their alma mater, or by the institution with which they are now connected, they will please send copies to the chairman.

WILLIAM T. MAGRUDER,
LOUIS E. REBER,
ARTHUR N. TALBOT,
HARRY W. TYLER,
CLARENCE A. WALDO,
CALVIN M. WOODWARD,
Committee.

JOINT SESSION OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS AND THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.

The joint session of the American Institute of Electrical Engineers and the Society for the Promotion of Engineering Education was held in the auditorium of the Natural Food Company, Niagara Falls, New York, on Friday morning, July 3. A complete report of the proceedings follows.

President Scott called the meeting to order at 9:30 A.M., President C. M. Woodward, of the Society for the Promotion of Engineering Education, being seated with him upon the platform.

President Scott.—The meeting this morning is a joint meeting of the American Institute of Electrical Engineers and the Society for the Promotion of Engineering Education. Professor Woodward, of Washington University, St. Louis, the president of the other society, is on the platform, and I take pleasure in presenting him to the members of the Institute present.

Part of the papers are contributed this morning by members of the Institute and part by members of the Society.

THE TEACHING OF PHYSICS TO ENGINEERING STUDENTS.

BY W. S. FRANKLIN,

Professor of Physics, Lehigh University.

I have been teaching physics to college and university students for nineteen years and I now have a few ideas on the subject which can, I think, be expressed independently of the subject matter and which may be helpful to others.

Some time ago, in talking with a practical engineer on the teaching of physics, I stated that in my opinion the ultimate object of the teaching of physics to technical students is to lead the young man by a shortened route to that familiarity with physical things which is possessed by such a man as John Fritz. The shortening of the route which leads to this result depends upon the fact that the teacher of physics has to do largely with an *epitome* of real knowledge, and consequently the primary object of physics teaching is, in my opinion, to develop in the young man's mind a logical structure consisting of the aggregate of physical conceptions and theories.

Since beginning the teaching of physics, I have never devoted any of the time of my classes to the discussion of the history of the subject. The best way to study an organic structure is to study its history, through the medium, say, of embryology, but this is the worst possible way to study a logical structure.

I have never on any occasion apostrophized the won-

ders of nature to any class of mine. The ability to measure electricity and the ability to calculate magnetism are really very simple and prosaic things, and any writer or teacher who for a moment allows himself to speak of these things otherwise than in explanation or in application, may be set down at once as attempting to lend an element of mystery to knowledge he claims to possess. It seems to me a very significant fact that in most of the cases that have come to my notice, the appeal on the part of a scientific writer to the reader's wonder-sentiment has been associated with very hazy, or entirely faulty, notions on the writer's part. I know of a text-book on physics which introduces the discussion of the doctrine of the dissipation of energy in the chapters on mechanics: this text-book actually would have it appear that the degradation of energy is essentially the change from the potential to the kinetic form, and the whole discussion ends as follows: "Tait calls available energy Entropy. The inevitable conclusion is that entropy tends toward a value of zero. In the beginning, then, it points to a period when all energy was available. With no less certainty, physical science points to a time when entropy shall become zero. All the processes of nature must then cease. Even the earth itself, as lifeless as the moon, can no longer circle round the glowing sun, but both and all together, in one dead mass, must hang in everlasting silence in the boundless night of space." Now, what I want you to keep in mind, is that this wonderful view adown the corridors of time is ostensibly based, in the book in question, upon a succession of egregious blunders.

I never have allowed the slightest speculative tendency to enter into any of my teaching, oral or written, and the extent to which many of our elementary text-books in physics indulge in imaginative nonsense and in weak phases of speculative philosophy is distressing to me. Nearly every text-book on physics that I know of defines the mass of a body as "the quantity of matter the body contains." I had the pleasure thirteen years ago of listening to a course of lectures by von Helmholtz on theoretical physics, and the first eight weeks or more of this course was devoted to the origin and meaning of our quantitative methods in physics. I thought at the time that von Helmholtz's statements were so simple and so apparently remote from the usual complications of physics that most of his hearers were likely not to appreciate what he said. Those lectures, however, stand in my mind as the most complete outline of the philosophy of the mathematical sciences ever given. All our notions of length and angle arise from and are defined by the fundamental geometric operation of congruence. The definition of mass is also a physical operation, the verbal definition is the briefest possible specification of this operation. The result of this operation on a given body is an invariant number, and by a feat of the imagination we are led to adopt this number as a measure of the "amount of matter the body contains." This is a notion of some mental utility although strictly it is mere imaginative nonsense. Several years ago I had occasion to review a well-known French book on "Electrical Measurements," the authors of which say "Une grandeur est une quantité susceptible d'augmentation ou de diminu-

tion. Une grandeur est dite mesurable quand on peut la comparer à une grandeur de méme espece et que la résultat de la comparison donne à notre esprit une satisfaction compléte.''

As an example of weak speculation, what do you think of the use in a secondary school book on physics of the following quotation from Maxwell as a means to clear up an inadequate discussion of energy? ''We are acquainted with matter only as that which may have energy imparted to it from other matter, and which may in its turn communicate its energy to other matter. Energy, on the other hand, we know only as that which in all natural phenomena is continually passing from one portion of matter to another.'' What do you think of the following from an elementary English text-book on physics? ''The fundamental property of matter, which distinguishes it from the only other real thing in the universe, is inertia. . . . We are now in a position to give one or two provisional definitions of matter —provisional because we cannot yet say, possibly may never be able to say, what matter really is. It may be defined in terms of any of its distinctive characteristics. We may say that matter is that which possesses inertia, or again since we have no knowledge of energy except in association with matter, we may assert that matter is the Vehicle of Energy.'' I wonder if any of you really doubt that every notion in physics, definite or indefinite, is associated with and derived from a physical operation, and that absolutely the only way to teach physics to young men is to direct their attention to that marvelous series of determining operations which bring to light those one-to-one correspondences which consti-

tute the abstract facts of physical science. If you do doubt this, I am bound to say that I do not think much of your knowledge of physics. I think that the sickliest notion of physics, even if a student gets it, is that "it is the science of masses, molecules, and ether." And I think that the healthiest notion, even if a student does not wholly get it, is that physics is the science of the ways of taking hold of bodies and pushing them.

In my opinion, the characteristic feature of science study, especially of the study of physical science, is a determining objective constraint upon the processes of the mind. I am surprised that this one important feature of science study is never mentioned in the many estimates that have been made of the value of science study in education, for as a matter of fact, that complete definiteness which is usually urged as the characteristic and valuable feature of science study is the fundamental condition of every psychological process, you say this or you say that, you go or you do not go, and even the classic mule standing midway between two similar loads of hay is in no danger of starving from indetermination. The psychological processes which are brought into play in the study of science do not differ from other psychological processes in regard to definiteness.

I say again that it is the completeness of objective constraint that chiefly differentiates the study of the physical sciences from all other studies and which makes the study of the physical sciences so important an element in any correct scheme of education. The importance of this objective constraint upon the mental processes in scientific work is most strikingly shown by

the entire absence of any such constraint in all of our crank scientific literature. I think that the full realization of this objective constraint in the teaching of physics depends first of all upon the making of one's teaching utterly and absolutely simple and homely, and devoid of all appeal to anything but the rigors of the scientific imagination. Anything beyond this is, in my opinion, idolatry.

I think that the ability to learn science by reading is a highly specialized faculty and that among average young men this faculty is nearly zero. I know many men who are quick to receive knowledge by experience, and quick to catch, from verbal description, manifold variations of their empirical knowledge, but whose imagination is wholly unresponsive to that abstract kind of writing which is so necessary in a concise treatise on the elements of physics.

Nevertheless, I think that the development of the student's imagination to the extent that is necessary to enable him to follow concise writing is one of the chief objects in the teaching of physics, and I do not believe that this result can be accomplished without requiring the student to use a text-book of the severest kind.

My idea of the teaching of physics is to use a sharply, clearly and concisely written text-book, to give explanatory lectures of such character as to appeal properly to the student's imagination (theoretical lectures, in fact, illustrated by the simplest kind of experiments), to require of the student a large amount of numerical calculation, and to give a laboratory course based upon highly generalized printed directions supplemented by

a vanishing series of verbal suggestions from an instructor.

I think that the chief object in a course in physics for technical students should be to give conceptual and analytical knowledge of the most important facts of physics. It is certainly better to know a little by reason, than much by rote. There is nothing in the teaching of physics so important as to develop in the student the ability to express physical conditions in mathematical form, geometrical or algebraic as the case may be, to reproduce or re-present the conditions of a problem adequately as a geometrical construction or as an algebraic formula. Nothing, I think, is so important as this for technical students. It is the very essence of effective knowledge of physics, and every bit of attempted instruction in physics which does not contribute directly or indirectly to facility in this re-presentation of physical fact in terms of our mental tools is in my opinion futile.

Many students and even teachers of physics raise the objection that a rigorous mathematical presentation of physics is highly unsatisfactory and uninstructive. They like such a book as the excellent new book of Edser's on "Light" which abounds in descriptions of phenomena and of the most recent researches on light pressure and the cause of comets' tails. Now, I am really interested myself in comets' tails, but I would feel like thrashing a young student who concerned himself about comets' tails and held his imagination unresponsive to a discussion of stationary wave trains and of reflection with and without change of phase. I have a contempt for a student who thinks he understands the

formation of a comet's tail but admits that such things as the kinematics of wave motion are beyond him. I recommend such a student to be honest with himself and study physics under the instruction of Jules Verne. Then he need not trouble himself about foundations, but he may follow his teacher pleasantly on a careless trip to the moon and with easy improvidence embark on a voyage of ten thousand leagues under the sea.

In my teaching of physics I have come to distinguish two distinct phases of laboratory work. One phase is that which is intended primarily to vivify algebraic formulæ—I think it is silly to talk of the verification of nature's laws (!) by a student—and the other phase of laboratory work consists of elaborate and precise measurements carried out with every possible precaution for the elimination of error.

I take pleasure in distributing to the Institute members here present a small pamphlet which I have had printed for this occasion as an illustration of the vivifying phase of laboratory work. The eight experiments described in this pamphlet apply to the direct-current dynamo, and I think that every technical student who studies physics to any extent should perform these experiments just to see the equations of the dynamo become alive. No one really knows much physics who is not able to look at an equation and see the manifold activities which the equation is intended to represent.

PRESIDENT SCOTT.—The paper of Professor Franklin, which presents the subject of teaching physics in a manner that is certainly quite different from the old idea, is now open for general discussion.

PROFESSOR GOLDSBOROUGH.—I had the pleasure of

hearing only the last part of Professor Franklin's paper, and I am sorry to say I have not prior to this time read the first part. If the first part is as good as the last part it is very good indeed. I very heartily agree with Professor Franklin in everything he has said. I think a great many of our colleges fail in teaching the boys mathematics on one half the campus, teaching them laboratory work on another part of the campus and never joining up properly the theoretical and what we might term the practical, whether in the dynamo laboratory or in the physics laboratory. If I catch Professor Franklin's idea correctly, what he means is that the boys should have a thorough and complete drill in theoretical electricity and then they should be taught to apply that theoretical training in practical work, and not be sent out of college with a theoretical training and a practical training which to the student have no relation to each other whatever. You would be surprised at the number of young men who have not any real definite appreciation of the link between the theoretical and the practical sides of their training; they do not seem to understand, and the trouble is, I think, that instructors very frequently fail to illuminate the formulæ as they go along. To my mind any text-book for students which has a certain number of mistakes in it, is not a bad thing—anything that will make them dig to find things. I know in my own experience, when I was at Cornell, an algebra was used there written by a gentleman who had taken one of the ordinary algebras and eliminated every other page, so that the student working over that would have to supply the matter that was eliminated. In other words, it was a concentrated

solution of algebra, and it was the finest thing in the world for the student. But the men who were administering that book, after they had made the students dig it out from the theoretical standpoint never left a page of it until they had given some practical method of supplying it in our engineering work. It is a magnificent thing for any man to have that kind of training.

It is the kind of training that they ought to have. Referring to what Professor Franklin says as to the equations of the dynamo, why, there are lots and lots of young men who know the equations of the dynamo, who know the equations of the alternating-current circuits, but there are comparatively few who feel thoroughly acquainted with them. They know them in a vague kind of way, but the ideas are involved and not made a part of themselves. I know myself, when I was a student I went around for two or three years saying "ampere" and "volt," and hadn't any more idea what "ampere" and "volt" were than I have of the proper construction of a flying machine. I don't know anything about it at all. It took time for those notions to sink into me. The first time that I tackled a problem in which self-induction was treated as a variable quantity, I didn't have any conception of what that meant, and it took two or three years before I had a concrete conception of what it meant to have variable self induction in a circuit, which they keep on telling us is assumed to be constant. It is not fair that we should hoodwink ourselves, believing we know something about a thing simply by assuming it is constant. We want to teach our men to build their engineering along rational lines. It is a perfect farce for us to introduce empiri-

cal formulæ into electrical engineering, because there is hardly one problem which we can solve without the use of a rational formula. Students very frequently come to me who have had training in certain mechanical subjects in which it is absolutely necessary to make use of empirical formulæ. They then want to jump to the last formula on the page, which shows the result, and constantly substitute that formula. I always make them go right back to the beginning and start and go right down through, and until they get what has gone before I do not think they have any business discussing the result. If we can have this method of instruction and these standards in our technical schools, we are going to have a wonderfully fine lot of engineers coming from our schools as time goes on.

Mr. Langsdorf.—My own experience in teaching dynamo laboratory work is not quite as long as that of Professor Franklin, but it has been extensive enough to show me that there are two ways of teaching the laboratory work. One method is to give the student at the beginning the equation which represents the relation among the quantities which he is measuring, and allow him to verify it by substitution therein of the data taken in the laboratory. The other method is to give him the apparatus, tell him to take the data, plot his curve, and determine the equation from the curve.

I think that by the latter method the thing is impressed upon the student as it can be in no other way. I remember that in my own experience as a student, when I had to derive the complete equation of the bifilar pendulum, its meaning was impressed upon me as no other method could have done it, and that is the method which I have since been using.

President Scott.—In this connection I think of a little incident in my own education. I do not care to make it appear as a reflection upon the teaching, but rather upon the pupil, or more definitely, upon the condition, or the atmosphere in the college lecture room and laboratory, as it was a number of years ago, and the atmosphere in practical life afterward. When I got out among workmen and engineers I found that there was one of the units for which they had the greatest respect, and that was the watt or the kilowatt. I remember when these terms first came to my office, that I remembered back, "Yes, the 'watt' "; and I remembered what had to be multiplied together to get the watt, and I remembered the ampere, and the volt, and the coulomb and the watt, and they had about equal importance and significance in my mind. When I got to the other end in actual life, the watt was the unit, the unit of work, the unit of horse-power, the unit of activity; we were dealing with energy, and these other matters were as full of scientific interest and value, but I had not got the practical atmosphere in the college which showed me that the unit of activity was the all-important one.

Professor Caldwell.—I never have had occasion to teach physics, but there are two points in the teaching of physics which the teacher of engineering would appreciate—one is the obtaining of exact results. I think that sometimes in physical departments one finds a tendency to great refinement of measurement but a lack of attention to the connection between measurements and absolute standards. That is, of course, by no means a general fault, but it is a tendency which one sometimes finds in physical work.

The other is in the matter of taking notes in the physical laboratory. It seems to me that the student should be impressed with the importance of the original notes which he takes. It is very common, I believe, to find that the main importance is placed upon the report sheets, and that not very much attention is paid to the way in which the original notes of the student were taken down. When he comes into the engineering work, then he has to unlearn that idea and learn the importance of his original notes.

President Woodward.—I will state to the gentlemen present that the Committee on Arrangements for this morning decided that Professor Jackson's paper would naturally come in between numbers one and two on the program of the electrical engineers, and that Professor Owens' paper would come in between two and three. Now, Professor Jackson's paper is here in my hands, but he is not here to read it. I know both these gentlemen are in town and will be here later; so if you will allow me, Mr. President, to shift them down, and you will proceed with your number 2, we will alternate after that with our representatives from the Society.

President Scott.—I think the intention of the arrangement suggested was to get the college professors in one group and the other men in another. We will mix the men a little. We will go now from a college professor to a manager, the head of an electrical contracting and construction and operating company, himself a college man, Mr. J. G. White.

THE PROBLEMS THAT ARE FACING THE ELECTRICAL ENGINEER OF TO-DAY AND THE QUALITIES OF MIND AND CHARACTER WHICH ARE NEEDED TO MEET THEM.

BY J. G. WHITE,
New York City.

Since the title assigned for this "paper" contains more than one per cent. of the total number of words allotted, there seems little room to speculate as to the problems confronting us.

To some engineers apparently the one and only problem is that of salary, while for others the greatest problem is to find men who *can* and *will earn large salaries.*

Other problems range from figuring the proper size of an electrical conductor or tracing out a telephone circuit up to the highest speculative imaginings of which the human mind is capable, such as those suggested by the recent statements of Professor Crookes, Professor and Madame Curie and others, regarding the atomic theory.

We are now told that each atom, formerly considered indivisible, is a whole stellar system, composed of a tremendous number of absolutely identical units, all in orbital motion.

We are further told that of these identical units or ions, an atom of oxygen contains 11,200; an atom of gold 137,200; an atom of radium 120,000; and so on.

Who can delineate the problems which will be presented by this new theory, or by the strange properties of the recently discovered radium and other radioactive substances?

A recent article on this new development says: "Chemistry has in fact become the astronomy of the infinitesimal. One is led to wonder then if the earth and the other planets are not mere ions forming a single atom of a higher universe, where perhaps they constitute a speck of dust that worries the careful housewife in the world next above us."

As, however, this is a body of educators and engineers rather than of astronomers and philosophers, may it not be well to avoid "speculation" and be content during the brief time at our disposal with what might be called a "plain three per cent. investment"?

The qualities of mind and of character needed by the electrical engineer of to-day are too well known to need to be specified.

He should be accurate in his calculations, thorough in his investigations, logical in his deductions, lucid and concise in his statements.

He should have untiring energy, an alert mind, abundant initiative, and reasonable self-confidence.

He should be absolutely honest in all his dealings, truthful in all statements, loyal to his clients, faithful to his employer's interests, considerate of his subordinates, diplomatic in his negotiations and tactful in all his relations.

However, instead of attempting to rear a structure on the foundation of the text assigned to us, may we not rather use it as a spring-board from which to vault into the general field under discussion to-day?

This might be summarized under the title, "What Education Should the Electrical Engineer of To-day Have"?

In entering this field, I realize that I may be trespassing on the preserves and vested rights of Messrs. Gherardi, Osborne and Johnston, whose papers are to follow.

In that case I hope these gentlemen will follow the example of the beasts in Kipling's Jungle Stories, and wish me "Good Hunting."

Irrespective of this, there are a few points in the education of an engineer which are so important that it would probably do no harm if they should be repeated and urged by every one of the men to whom papers for to-day's session were assigned.

One of these points is well covered by Mr. Johnston's paper, "Engineering English," the great importance of which is further emphasized in the latter part of this paper.

As is frequently remarked, this is the age of great industrial combinations and of specialists. Not satisfied with this, the specialists now specialize. The engineering field was formerly divided into the two general classes of military and civil engineers. From the latter gradually developed marine, mining, and mechanical engineering, and as an offshoot from this last branch, there was recently added electrical engineering. Civil engineers to-day are subdivided into such classes as "hydraulic engineers," "bridge engineers," "railroad engineers," etc. We also find that electrical engineers are classified as "telegraph engineers," "electric light engineers," "electro-chemical engi-

neers,'' ''telephone engineers,'' etc. A few years ago many of us would have supposed that the ''problems'' of the ''telephone engineer'' were those of a high-class artisan and that they would consist largely of trying to unravel tangled cobwebs of fine wires, and to understand and to be able to operate mazes of signalling, connecting and protecting devices. A member of the Institute of Electrical Engineers, who is the head of the electrical engineering school in a prominent university, remarked not long ago that he never appreciated the importance of the ''telephone engineer'' until he saw one of the particularly well-known members of the profession decline a salary of $25,000 a year. The professor further stated that ever since then he has wished he knew enough to be a ''telephone engineer.''

In the early days it was thought that a room of almost any shape and size, with a couple of empty boxes for seats, and a switchboard of primitive design and construction was all that was needed to make a telephone exchange. The city of New York had in 1894 about 10,000 telephones or ''stations''; in 1900 the number was about 45,000; at present the number is in the neighborhood of 100,000, an increase of 1,000 per cent. in nine years, and by 1910 it is estimated the number will be perhaps 300,000. These figures are understood to be exclusive of desk or other extension sets.

Owing to the wonderful growth of their business, telephone companies now erect buildings specially designed to meet the requirements of their exchanges, and a ''telephone engineer'' must know something of architecture, the strength of materials and other factors

entering into modern steel building construction, and many other subjects which should be a part of a broad engineering education, but which are not ordinarily supposed to come within the province of a "telephone engineer," as narrowly applied.

It is at least equally important that other engineers who have specialized and must know well some part of the field of engineering, should likewise have a general knowledge of the sciences and of the broad underlying principles of engineering, based on a thorough mastery of elementary mathematics, and supplemented by some study of languages, history, civics, and other studies of general educational value.

The question naturally arises, how can the engineering student possibly secure a satisfactory knowledge of all of these important subjects? Much of his special knowledge must be acquired after he has commenced the practice of his profession. If unusually energetic and capable, all or any part of his education may be gained after he enters professional life, but it is preferable that his broader education be well started during his school years. For a considerable time it has been clearly recognized that law and medicine require, for general and special study, more time than is possibly available in the ordinary college course of four years. The well-educated lawyer of to-day takes a thorough preparatory course, four years in college, and three, or at least two, years in law school, and after this is likely, if he can afford it, to take one year abroad or in some special post-graduate work. The well-educated physician of to-day, after regular and preparatory courses, spends three years in medical college, and if

possible one year in foreign study, and then is likely to devote several years to hospital work before attempting to engage in the general practice of his profession.

If lawyers and doctors can afford the time and money necessary to get such educations, should not engineers, in view of the very wide range of subjects with which they must now be reasonably familiar, adopt a similar plan? The decision of this question will have to be made individually by the young men themselves, important factors being the time and money available for educational purposes.

It is well to remember, however, that more important than a knowledge of any study, or group of studies, is the ability to master thoroughly any subject of which a knowledge is desired.

In education especially quality is more important than quantity. A thorough mastery of arithmetic and algebra is better than a mere "pass grade" knowledge of these and all the higher mathematics, which is then ordinarily soon forgotten. It is better never to have seen the inside of a Latin, French, or German grammar, and to use correct English, than to have the ordinary three or four years "translating knowledge" of all three of these foreign languages and still say: "I seen."

As in nearly all practical engineering problems, this one of engineering education can perhaps be best set forth by arranging a balance sheet showing the credit and debit sides. Against the extended education we have expense involved, time necessary before the earning period is reached, time required for general study which might be devoted to mastering some special

branch of engineering, thus more quickly insuring a comfortable salary, danger to health if too much study is crowded into a given period, etc. On this side also we have the danger that by widely extending the field of endeavor we may produce a student rather than an engineer, or that the work may be superficial. The importance of thoroughness is supreme.

This implies also that the education of the engineer must develop not a dreamer, but a worker, thoroughly competent in his sphere, whether great or small.

It is better for the world and for the man that he should be a high-class mechanic or artisan, with a good common school education than that he should be nominally an "engineer," having a smattering of many subjects, and eking out an existence amongst more competent fellows.

It is better for him never to have been inside a college, but to have commenced at wheeling ashes and become a good electric light superintendent, than that he should "drag" through college and university, take master's and doctor's degrees and become an incompetent college professor. His social status may not be as high, but he will be a more useful man.

On the credit side of the extended education we have, first, the direct satisfaction to be had from its possession and the ability to enjoy on even terms the society of educated people.

Secondly, there is the practical use to which this knowledge can be put.

Third and more important than the knowledge actually acquired, is the learning how to know a subject, and where or in what direction to look for information specifically wanted.

Fourth, there is the certainty that with equal industry and attention to his work, the young engineer of ability with a broad education will ultimately take higher rank in his profession and be more successful in business.

The qualified phrase, "young engineer of ability" is used advisedly. The engineer of ordinary or less than ordinary ability will, in practical life, accomplish most by not attempting to have his education cover too wide a field, and learning some special department thoroughly.

A prosperous market gardener is more to be envied than a poor farmer.

If a young man will take for his motto "thoroughness," and, in planning his list of studies, will include first those of prime importance, and then add those of decreasing importance, until all his available time is occupied, he will be planning most wisely. Ordinarily the young man will not be able to arrange a course entirely to suit his individual requirements, but he can use the method above suggested to help him in deciding as between various courses offered. The choice should, when time and mental capacity make it possible, be in favor of a broad general education, supplemented by thorough technical training. This may, and frequently will, lead to a general college course to be followed by a technical course of two or more years.

The writer recently knew of two groups of men who were each looking for an able street railway manager, and who were willing to pay in each instance a salary of $25,000 per annum. The man who happened to be offered both of these positions is said to have been for

twelve years a street car conductor. This is no proof that an engineering education is valueless. It is, however, conclusive proof of the superior importance of good business judgment and the ability to thoroughly master a given subject—which in this instance happened to be street railway operation and management.

People are to-day looking for engineers and would gladly pay salaries of $6,000 to $10,000 per annum for men of exactly the right qualifications. It would be easy to find hundreds of men who have had all the necessary general education, and scores who have had as well all the needed technical training. The questions which are asked, however, are such as the following:

Has he good business judgment?

Has he tact?

Has he the mental capacity and breadth to develop into a "big man"?

Is he diplomatic, with ability to negotiate?

Has he initiative, without being erratic?

Will he get results?

We might divide the studies which are worthy the attention of the electrical engineer into four general classes. Individual opinions will necessarily differ widely as to the studies which should come within each class. Some will want to increase and others diminish the total number. In any event, the student should attempt studies of the relatively less important classes only in case he has already mastered thoroughly, or is sure of so mastering, the more important studies.

In the first class we may put those studies which will teach to think clearly and express lucidly, which will

teach how to learn, and which will give a comprehensive knowledge of the fundamental facts and principles underlying his profession. These should be learned most thoroughly, and would include English, arithmetic (mental and written), algebra, geometry and trigonometry, chemistry, physics (especially mechanics), general knowledge of principles of electrical engineering, practical ethics.

The second class may include some subject which will especially tend to further develop clear thinking and clear writing, some which will further increase the knowledge of the general principles of his profession, and some which will give knowledge which will be professionally and commercially useful. This class includes calculus and vectors, surveying, Latin (usual preparatory course), French (speaking and reading—not translating knowledge of), electro-chemistry, advanced engineering studies, business law, general principles of modern accounting, civics.

The third class may include some subjects which are likely to be of direct professional or commercial use, and others, the study of which will be of general educational value. This class includes Spanish, geology, physiology and temporary care of injured, logic, quaternions, and subjects which are studies of engineering details rather than of general principles, etc.

The fourth class may include those studies which will help in rounding out the education of the man rather than in furnishing the essential equipment of the engineer. This class includes mineralogy, botany, zoölogy, history, political economy, mental and moral philosophy, art, music, etc.

The third and fourth classes of subjects are useful to round out and complete the foundation and framework provided by the first and second classes, but should not be indulged in at the expense of the relatively more important. A few non-technical subjects merit individual mention.

English.—President Butler, of Columbia University, is reported to have said: "The first two evidences of an education are correctness and precision of speech, and refined and gentle manners." The latter must be acquired almost entirely at one's home and from contact with one's associates. The correct speech must be acquired largely in the same way, but may be learned to a considerable extent, in the preparatory schools and in the college or university. There is nothing more important for the young engineer to learn than "the skilful and correct use of language, whether to state a fact or convey an idea," understanding that "clear thinking precedes clear speaking."

English should be taught from beginning to end of the preparatory school work, and also from beginning to end of the college course. In order to have this drill continue throughout the college course, it may be necessary to have a considerable part of the training incorporated into the writing of laboratory reports, examination papers and other similar documents. Is this not feasible? Whether done in this way or not, the training should be continuously maintained.

Arithmetic and Algebra.—More attention may well be paid in the preparatory schools to algebra and arithmetic, especially mental arithmetic. A comprehensive understanding of algebra is most useful to the engineer

both in his later studies and in practical work. Mental arithmetic provides both good mental exercises and equipment.

We sometimes hear engineers, as well as others, speak of the "poetry of motion." Many of our profession seem to understand this only as applied to the slide rule. It is unnecessary, and is frequently annoying, to have an engineer who is drawing a salary of several thousand dollars per annum, pull out his slide rule, and after some considerable manoeuvring, announce that "five times four and one-half is about twenty-two," or that "two tons of rails at $33 per ton will cost about $65.

Surveying.—During the college course it would seem advantageous even for the electrical engineer to devote a moderate amount of time to the study of the various methods of surveying now practiced. These can be quickly understood if the student has thoroughly mastered his arithmetic, geometry, and trigonometry, and a general knowledge of surveying is very likely to be useful in practical work. A summer spent on railroad location and construction will help develop one's physique, teach one to read and fully appreciate a profile, give a little knowledge of construction costs and methods, and give other knowledge which one will probably find useful in both field and office. A summer so spent will in after life be remembered as time well and profitably occupied.

French and Latin.—French and Latin are included in the second class, because of the mental training and polish to be gained by their study. Some knowledge of Latin will greatly assist in thoroughly mastering

English, and is in this respect more useful than the study of German.

A knowledge of French which will enable the young engineer to speak and read with ease is strongly recommended. The educated people of Mexico, South America, Russia, and other countries speak French, and as this for centuries has been the polite and diplomatic language of the world, the advantages to be derived from mastering it are likely to be not only educational and social, but commercial as well.

On the contrary, there is little prospect that American engineers can practice their profession profitably in Germany or German-speaking countries. Nearly all important scientific papers are now promptly translated into English, and included in the technical press or publications of the various scientific and engineering societies. In consequence, there is no longer any special need of the engineer knowing any foreign languages for the sake of keeping advised as to the progress made in the work of his profession.

The general educational value of learning one modern language seems about equal to that to be gained from learning another. Consequently the social and commercial advantages of French give it first place for the American engineer.

Spanish.—The study of a second modern language should be undertaken only in case the first can be spoken fluently. Then it would seem that Spanish is the best language to learn. Having studied Latin and French, Spanish should be very easily acquired.

The development of Porto Rico, Cuba, the Philippines, Mexico, the Central and South American coun-

tries, will probably afford many opportunities for the engineers of the coming generation, and to these a knowledge of Spanish would be of great value.

Engineering Studies.—The time devoted to various engineering studies in class 1, as well as class 2, must depend largely on the facilities of the college attended, and the special work for which it is intended to prepare. It would be quite useless to attempt to discuss the relative importance of the purely technical studies in the time at our disposal, or to attempt to arrange any detailed plan of technical work.

Business Training.—Somewhere in the general course there should be included a moderate amount of training in modern business methods and practices. There is no more reason for the engineer graduate being utterly ignorant of even the most elementary knowledge of business practices than that he should know absolutely nothing of geography.

Accounting.—All engineering students should have some reasonable training in accounting, so that they would not be entirely ignorant and without power of speech if, after beginning the practice of their profession, they are asked some elementary questions about the annual report of a street railway, electric light or manufacturing company.

Business Law.—A moderate amount of time should also be devoted to the study of fundamental principles of business and corporation law. An engineer, in practice, should at least be able to draw a contract which will be legal and explicit.

In General.—A modern engineer is dependent for his success largely on the financier. If the engineer does

not know that bonds should pay interest, and that stocks, if possible, should pay dividends and has no conception of the difference between a stock certificate and a promissory note, the financier is likely to form an undeservedly low opinion of the engineer's technical knowledge.

If a young engineer will have before him constantly the ultimate and best interests of his employer, will endeavor always to be tactful and never to unnecessarily irritate, will—without flattery—say only what is pleasant, unless right demands a plain statement of an unpleasant truth, then his advance will surely be more rapid than if these things are forgotten or neglected. The importance of these things should be pointed out and frequently emphasized by educators.

The technical problems which face the engineer are certain to be recognized as they come up. Too frequently the importance of problems connected with one's business and social relations with employers, fellow employees and others are not appreciated. These deserve careful and persistent study. Their correct solution and an accurate appreciation of the proper proportion of things, constitute business sagacity. The paramount importance of such matters should be repeatedly impressed on students and they should be led to understand thoroughly that their satisfactory solution will be rewarded not only by a pleasanter life during working hours, but also by increased esteem and greater business success.

President Scott.—You will note that our papers prepared on behalf of the Institute are of one class. In laying out the plan of the educational papers it was

thought that we would for once put the college professor in the background and let him hear from the men in practical life as to the qualifications desired of engineers who came to do the work for the different companies engaged in different lines of work. The first paper, by Mr. White, deals with the general problems. Mr. White, as I intimated at first, is at the head of a company which employs a large number of engineers in different lines of activity, mainly in the laying out, designing, building, and operating of power plants. The next paper deals with the subject from the telephone standpoint. Mr. Gherardi, who is the chief engineer of the New York and New Jersey Telephone Company, is not present, but Professor J. P. Jackson, I believe, is to present his paper.

Professor J. P. Jackson read the paper referred to, as follows:

THE PROPER QUALIFICATIONS OF ELECTRICAL ENGINEERING SCHOOL GRADUATES FROM THE TELEPHONE ENGINEER'S STANDPOINT.

BY BANCROFT GHERARDI, JR.

Mr. President and Gentlemen:

I have been asked by the Chairman of the Papers Committee to say a few words on the proper qualifications of electrical engineering school graduates, judging them from the point of view of the telephone engineer.

These qualifications are the product of two factors—the natural ability of the man himself and the training which he receives at the engineering school.

The man's natural ability, although a factor of prime importance, I will not, owing to the limitations of time, attempt to speak upon in detail here to-day. In general terms the nature of these qualifications, which seem to me to be requisite in the engineering student, is evident from a consideration of the training which the school attempts to give him, for if he is to obtain anything of value from his school training, he must have those qualities of mind necessary to enable him to assimilate it.

In treating my topic, I shall confine myself to a discussion of the subject of education considered not primarily with reference to preparing the student for his general responsibilities with reference to society, but solely as providing him with the special qualifications needed in his professional work.

In thus excluding from the present consideration the question of what education should be given to the student for other reasons than to fit him for the special work of his profession, I do not wish to belittle the very great importance of broadening studies. A discussion including this phase of engineering education would extend my remarks beyond the time assigned to me, would develop age-long controversies and would perhaps, after all, be more suitable for discussion elsewhere than at this meeting. Even that branch of the subject to which I have restricted myself is so extensive that it will be impossible here to treat of it exhaustively and at best I will only be able to bring out a few ideas which have impressed themselves upon me as being worthy of serious consideration.

It is well recognized that telephone engineering is one of those specialities into which electrical engineering in general is rapidly splitting itself, and in consequence of this fact, it has been assumed by some that the school training for the telephone engineer should be different from that given to electrical engineers in the other branches.

That the telephone engineer should receive at the engineering school a training substantially different from that given to electrical engineers in other branches is a proposition with which I do not altogether agree.

While the professional work required of the telephone engineer, comprehensive though it is, brings him in contact with various practical problems which do not confront electrical engineers in other branches, his work is, after all, based upon the essential principles which underlie the work of all of those engaged in the elec-

trical engineering profession. It deals with the same materials and the same physical laws and it has the same general object in view, that is, to accomplish the most satisfactory results in the most economical manner.

If, in the few short years which are available for the professional training of the student, it were possible to teach everything in science and engineering which might be available in his professional work, it might then be reasonable to incorporate as a part of such training a large amount of work on problems particularly concerning the telephone plant and the questions which arise in the construction and operation thereof. It is evident, however, that to include in the curriculum such a course of training would far transcend the limits of time which the student can spend at the engineering school. It seems to me, therefore, that instead of attempting to teach these ultimate practical problems, the important matter is that engineering students should have discipline in the methods of solving engineering questions. Such discipline as I have in mind is not given by teaching him the solution of each and every question that may arise in practice, even if the time available would make this possible. On the contrary, this discipline can best be given to him by a general training which will enable him to solve any question that may arise when he becomes acquainted with the conditions of that special problem. When the special problem comes before him, he will, with the proper training, be able to solve it first by getting the facts in the case and then by interpreting these facts according to correct processes of reasoning.

The function of technical education in my mind, therefore, may be summed up as follows: Train the student so as to convince him of the necessity of getting his facts and teach him the best method of getting the facts. Train him as to the methods of interpreting engineering data and in reasoning thereupon. You will note that I do not say that the education should teach a man the facts. It seems to me it is evident to any one who considers the question that no course of college or university education can teach a man the facts and practices of such a field of engineering as we have under consideration. I do not refer to fundamental facts and laws, but refer to the details of superstructure with which so many special courses endeavor to familiarize a man before he starts on his professional career.

The state of the art in the case of any branch of engineering is necessarily voluminous and involved and is constantly undergoing rapid changes. The mere acquiring of such voluminous data and ascertaining their correct relations to other data is the work of a lifetime, even assuming that such data were available in a form which would permit of their being taught in a university or college. Furthermore, and what is more important, the attempt at teaching such data in the length of time available necessarily results in the neglect of those fundamental and general studies, the importance of which I am endeavoring to bring out.

If I were to consider the extent to which broadening or liberal studies should be required of the student, the question of how much time should be devoted to English literature, to logic and to philosophy, would require

most careful consideration, but upon one point which might properly come under the head both of broadening studies and special technical equipment I have firm convictions. I shall speak of it here merely as part of the technical equipment of the student.

I am satisfied that extraordinary efforts should be made to teach every engineering student to write a report or letter in clear, convincing English, setting forth the facts and arguments and conclusions pertaining to any question he may have to consider. The student should be taught to state in correct and logical form the nature of any given problem and to enforce his conclusion with arguments which must be convincing. Such training as this is not one merely in literature, composition, or rhetoric, for it should be borne in mind that to write such a report as I have indicated, the student must, first of all, have mastered the problem itself, and that clear thinking must precede clear writing.

From this point of view, discipline in English is not to be regarded as producing mere literary polish, but as enforcing correct thinking in regard to each and every question upon which he has to write. If rigidly applied throughout all of his college course, this will do more than any other single form of discipline to develop correct habits of thought.

In mathematics the usual training leading up to and including the calculus is sufficient for general engineering work in telephony, although it is well for men having special aptitude in mathematics to carry their work sufficiently far so as to be able to handle problems involving differential equations. The relatively small

number of questions in practice, however, demanding this knowledge of higher mathematics, does not justify requiring it of every graduate, particularly as those not having aptitude for it would not be able to make much use of it in practice. A student should receive a good training in elementary physics and analytical mechanics, and should be familiar with the application of analytical mechanics to engineering problems. In electricity, the student's work should of course be carried much farther than in the other branches of physics, and he should have a thorough knowledge of both direct and alternating currents. In addition to giving him this knowledge in the abstract form it should also be taught in some of its principal applications to the several branches of electrical engineering.

In experimental laboratory work he should have a fair amount of experience. This laboratory work should be chosen primarily as illustrating and proving fundamental laws and also as giving the student the necessary manual dexterity needed in handling instruments of precision. As an important part of such experimental work, I suggest that all electrical engineering students should be thoroughly drilled, not only in general electrical testing, but in the special electrical resistance and electrostatic capacity, as well as to their dielectric strength and other essential physical and electrical properties. Such experimental work should also include some fundamental tests of prime movers as well as standard tests upon generators, motors, transformers, and storage and primary batteries.

In the time allotted for this laboratory work, a due proportion should be set aside for selected experiments

relating to the telegraph and the telephone. The student should also receive a general knowledge of the materials used in engineering work, both from instruction and from laboratory tests.

In the matter of shop practice, I think it is easy to run to excess. A certain amount of practical experience in shop work should be given to the student so as to familiarize him in a general way with various classes of shop practice. The effort here should be not to make the student a skilled workman, but rather to give him such respectful familiarity with the problems of the work shop that he will have a just regard for their possibilities and limitations. He should be so trained that when in his professional work he is brought into contact with the shop foreman, he will be able to coöperate successfully with him.

One or more foreign languages and drafting are everywhere recognized as standard requirements of an engineering education, and should not be neglected in the course under consideration.

It does not seem to me that any engineering education is complete without a certain amount of knowledge in regard to legal questions, particularly those relating to the legal responsibilities of engineers, to the execution of work under contract, and to the matter of patents. Nothing, of course, should be undertaken at the engineering school in the way of attempting to give to the student such a knowledge as will enable him to dispense with legal advice upon such questions, but he should be provided with sufficient knowledge to enable him to know when to seek legal advice and to be able to lay his case before the lawyers and to give to them

all of the facts which are essential to the proper consideration of the question which may have arisen.

While I have laid stress upon the necessity of a preponderance of fundamental studies in the electrical engineering schools and have argued against the tendency to multiply subjects of study by introducing excessive numbers of courses dealing with the details of engineering questions, I do not by any means wish to be understood as desiring to exclude altogether from the studies a goodly number of examples from practice. I would use the examples from practice, however, as illustrating the fundamental laws and as showing how apparently remote scientific principles are really of the utmost importance in the solution of practical problems.

In choosing the practical examples with which to illustrate a given fundamental principle, care should be taken to select one or more cases from each branch of electrical engineering to which the fundamental principle may apply. In this way the value of the principle will be borne in upon the mind of the student. It will help him to see theory and practice in the proper perspective and if the examples are well chosen and judiciously placed before the student, they will aid him in deciding upon the particular branch of electrical engineering for which he is best fitted.

At the same time these practical examples, although they may be relatively few in number, will, if adequately treated, not be without some immediate practical value in the student's early professional work.

If the attempt to teach practice is thus restricted, it will, in my judgment, give the desired balance to the

theoretical training and go as far as the college should attempt to go in fitting the student for his practical work after graduation.

The Papers Committee have asked me to include in my remarks any criticisms that might occur to me as a result of my experience with technical school graduates. In complying with their request, there are two or three points which I wish to emphasize.

In the first place, many graduates do not seem to appreciate sufficiently that engineering is the determination of the most economical way of accomplishing a desired result. In too many cases they feel that they have done all that is required when they have determined one way of accomplishing a result, and as soon as they have found that way, deem that the question before them is answered.

This state of mind upon the part of a student who has recently graduated and who has never felt the burden of final responsibility is not unnatural, considering the conditions under which his work has been done at college. There, while he may have been taught to look carefully for the most economical solution of a given problem, he could not from the nature of the case be confronted with the severe penalty which falls to a professional man who has failed to obtain the most economical answer to an engineering problem involving large sums of money. The importance, therefore, of earnestly and fairly considering all possible solutions of the problem in hand should be continually impressed upon the mind of the student.

Many instances have arisen in my experience which lead me to believe that notwithstanding all that is said

upon the subject, not a sufficient amount of emphasis is laid upon accuracy. I have often noticed that beginners in engineering seem to feel that an arithmetical error in their work, or an inadvertent making use of one figure when they should have used another, or carelessness in getting together their data, are comparatively trivial mistakes, while the use of incorrect mental processes in endeavoring to attain a result is the only kind of mistake which would be regarded as serious.

Without in any sense condoning the use of incorrect mental processes, I wish to point out that as far as practical results are concerned, errors of the one kind are quite as serious, and render the result of as little value as do errors of the other kind. As a matter of fact, these clerical and arithmetical errors are often more serious in their consequences than errors in logic. Errors of logic can readily be determined by a comparatively brief examination of a subject by a competent chief engineer, whereas errors in computation and clerical errors cannot be discovered without going over in full detail the entire work of the subordinate. No qualities of mind, therefore, however admirable they may be in themselves, are sufficient to compensate for this class of errors which I am now condemning. It would have a very wholesome effect, therefore, in dealing with these errors which are so often condoned in the student's college work, if the instructor would force upon the attention of the student the necessity for accuracy in this respect, and point out to him the unfortunate results upon his future career, which errors would produce if they occurred in his professional work after graduation.

Cases have come under my observation which show that often graduates have too little appreciation of the relations between their theoretical knowledge and practice. They seem to feel that practice is a matter altogether apart from theory, and have no physical conception of what corresponds in nature to their theoretical information. This, no doubt, is in some cases due to a lack of ability on the part of the student to grasp and comprehend his theory, and in such cases the defect cannot be overcome by any amount of training. In too many cases, however, I feel that it is partly or altogether the result of the training which the student received in the technical college. This defective method of training might be illustrated by a course of laboratory experiments carefully laid out and described in a text-book with which the student is supplied. Specially prepared apparatus might be set up and wired permanently to one or more set switchboards in the laboratory in such a way that the student might, with a minimum of thought and effort, and by following his text-book, which carefully describes the experiment, go through the form of making the tests, carefully entering the results of each test upon printed forms, kindly prepared in advance for him and having upon them a space to enter the result of each observation. For a student working under such paternal conditions, it would be well-nigh impossible to fail to make the experiment and record the result of his "laboratory work" correctly. By such a plan as I have outlined the student can complete a course of laboratory practice without having gained the slightest conception of the physical phenomena underlying the experiments which

he has made, or of the relations of these physical phenomena to the general laws which he has learned in connection with his theoretical work. While such conditions as I have outlined might seem to represent a state of affairs not existing in any of our technical schools, nevertheless it is to be feared that in many cases too great an approach to them has been made.

If the few ideas which I have here expressed are understood in the spirit in which they are intended, there will be little danger of my being considered a hostile critic of the engineering school and its graduates. So high is my appreciation of the work of our American engineering schools, and so warm is my regard for their graduates, that I wish to guard against that little danger. This I felt that I can best and most briefly do by stating that, with rare exceptions, the possession of an engineering school training is a requisite for entrance to my office work, and the net result of my experience with engineering graduates shows that the training which they receive, notwithstanding its imperfections, is of great value to them and to those for whom they work.

President Scott.—Most of the electric manufacturing companies have on their engineering staffs, and also on their executive and administrative staffs, young men who are college men, technically trained engineers. One of the men of that type who has come up rapidly—it is only a dozen years or such a matter since he left school—is the author of the next paper. He has come up through various technical and administrative branches of the company with which he is connected, until he is now one of the vice-presidents. He has had

much to do with providing the equipment of men for the company. The company uses material, and it uses men also, and it is getting to be quite a study as to the kind of men, where to get them, how to train them, in order to qualify them for the large and varied responsibilities of a manufacturing company. I regret that Mr. Osborne is not present. I will ask Mr. J. S. Peck to read the paper.

THE PROPER QUALIFICATIONS OF ELECTRICAL ENGINEERING SCHOOL GRADUATES FROM THE MANUFACTURER'S STANDPOINT.

BY L. A. OSBORNE.

Any discussion having for its subject the educational needs of a student of engineering must necessarily be limited to the particular requirements to be met. It is therefore proper to state in the beginning that the writer has in mind the requirements of a particular industry and his views are therefore controlled by the environment with which he is most familiar.

It is probable that the majority of young men who enter upon a course of engineering in one of our technical colleges rarely have expectations of devoting their energies to engineering pure and simple. My experience has shown that the average young engineer rather expects that his preliminary training and education will be of assistance to him in obtaining a foothold with the commercial side of industries which are based upon engineering practice. It is not obvious, in seeking for reasons for this attitude, whether our engineering courses are based upon the assumption that the industrial world requires business men with a technical training, or whether the supposedly larger emoluments which come to men of affairs rather than to specialists and designers, has its effect in diverting the energies of young men after they have departed from the influences which surround them in their academic career; but I believe that the latter is the determining factor.

However that may be, my experience is that of all the technical graduates who obtain employment with the industry with which I am connected, not more than one in ten is fitted either by temperament or education to take up with success the work of pure engineering.

Temperament undoubtedly has a great deal to do with it, and the tendencies of modern industries to demand technical training of men in its commercial departments undoubtedly has the effect of inviting men to take the technical courses, where if there was not that incentive they would have devoted themselves to some other line of activity. There is therefore graduated every year a large body of men who are added to the engineering profession but who are not properly fitted to deal with engineering questions broadly.

On the other hand, the courses which these men have followed have generally not pretended or considered any other probability but that they are to become engineers pure and simple. There have consequently been turned out a body of men who are by inclination not prepared to follow the so-called drudgery of the profession. At the same time they have been given little instruction or special preparation for the lines of work into which they will obviously drift.

I cannot but believe that the majority of men before they have completed a four years' course in college have given some indication to the faculty of their ultimate tendencies. It seems, therefore, as if it were desirable either to differentiate between these two classes of men, with the result that each would be better prepared for the work which they will ultimately be called upon to do in the world's activities, or better still to

broaden out the courses in certain particulars to the end that the whole body of engineers will enter upon their work with a fuller comprehension of its duties and its opportunities.

I am quite aware that financial and physical limitations will always render the attainment of an ideal at the best only an approximation. I know from personal contact with many of our educators that they are fully awake to the growing demands of the profession, and that generally the most earnest efforts are being made to meet these ever-increasing requirements. My remarks should therefore be taken in the spirit in which they are given, that is, not in criticism of existing methods, but as an endeavor to point out conditions which might be considered as desirable to work toward.

In considering whether the training of the modern engineer is adapted to the demands which will be made upon him later on, we should bear in mind certain latter day tendencies which have largely come about through engineering practice.

There was a time in the history of manufacturing when its activities were directed largely by men who had grown up from apprentices in the shops and who were primarily machinists and workmen. The work of modern engineering has resulted in the development of enormous industries which require skill, intelligence and knowledge and a high order of administrative ability, which was entirely unnecessary in the days of small shops and limited organizations. It has followed that the problems incident to this great industrial development have been more than the limited education and intelligence of the old-time shop superintendent could cope with.

The inventions and discoveries which have revised modern industrial practice have been made by comparatively few men. The activities which have been consequent upon these inventions and discoveries require an army of trained men to supervise and direct them. It is in this field that the average engineer can hope to find an outlet for his best talents. I am not now speaking of the few men who by temperament and by making the best use of the opportunities offered in the technical colleges will ultimately develop into world-recognized engineers, but of that great body of men trained in engineering, who must look to the more general fields for a proper environment in which to exercise their abilities.

In this short paper it is not my intention to do more than to point out suggestive thoughts, hoping that the discussion, which is always more important than the paper itself, will bring forth the opinions of our members on this question, and will do much to aid us in defining our views upon the subject.

Considering the field of manufacturing, it is my experience that not one in a hundred engineering graduates ever looks to that as holding forth anything attractive as a scene of his future labors. Manufacturing today in any industry is a proper field for an engineer. It is unnecessary for me to set forth the countless opportunities which any manufacturing concern, be it great or small, offers for the exercise of engineering judgment.

It is true that our technical colleges devote a certain portion of their time to "shop work," and endeavor to give to the engineering student a certain facility in the

manipulation of tools, both hand and machine; but it is very rare that the college makes any serious attempt to take up those larger questions of the adaptation of tools to special purposes or give instruction in general in the principles which underlie the tool organization of a shop. Consequently the student's interest is not stimulated, and the majority of the technical college graduates leave college with but very hazy notions either of the function of tools, the principles of their design or the machine organization of a shop. In connection with manufacturing it is also certain that a more thorough knowledge of works organization as applied to the personnel, would not only stimulate the interest of the student in this most attractive field, but would be of the greatest importance to his future employers, the industrial concerns throughout the land.

Almost without exception, an engineering graduate enters a machine shop in utter ignorance of the principles which should underlie its organization and personnel. It is true that familiarity in these lines comes largely from experience, but it is also true that there are large fundamental facts underlying all successful examples of shop practice and shop organization, which should be of the utmost value to an engineering student.

Another very important function of the man whose work is the supervision of manufacturing processes, is the subject of works accounting. Works accounting based upon general accounting practice is a closed book to the average student of engineering. I have been unable to find in the curriculum of any technical college that I have examined, any course of study which remotely suggests that this would be desirable knowledge

for an engineer. The matter of shop accounting is not a matter for the ordinary expert accountant to deal with. The man who knows the cost of his product—and upon this knowledge success absolutely depends—must adapt the fundamental laws of accounting to the particular cases with which he has to deal. There is no more important knowledge required of a works manager than an adequate knowledge of proper accounting methods. In criticism of this it might be said that ordinary accounting and bookkeeping is a thing which any intelligent man might readily acquire, but my opinion is that it would be much better for our engineering courses to recognize the important relation which this branch of knowledge has to modern engineering work and the advantage of including it in the curriculum would lie in bringing the importance of the subject prominently to the student's attention.

All engineers, if they expect, as all do, to achieve prominence in their profession, must sooner or later come in contact with labor. There is no more vital subject facing the industrial world to-day than the relations between employers and labor. Every engineer may hope sooner or later to be an employer of labor. To enable the engineering student to understand the economic laws which govern the relations between employers and labor, would add enormously to his value in a general way. The engineering student to-day has no insight into these questions except as he may gather his opinions through the newspapers or through such desultory reading as he may choose to do; the result is that the engineering student is not brought to an appreciation of the enormous influence which this question

must have on our future industrial progress. A course which would bring to the student's attention the history of the relations between capital and labor and the economic laws relating thereto, would be suggestive and call to his attention vividly its importance, and arouse in him a realization that this is a question which he some day might be called upon to treat intelligently.

On the commercial side, all engineers sooner or later must come in contact with the problems which introduce questions of business practice. The consulting engineer, the engineering salesman, and the designing engineer will, sooner or later, be called upon to enter, either directly or for his employers and clients, into contract relations. As it stands to-day the engineering student leaves college with the haziest notions of the principles underlying the law of contracts. Under the circumstances it would seem well if our engineering courses included a short course of law in its relation to contracts.

It may be said that all these things have nothing to do with engineering. This is partly true, but my plea is for engineers of broader horizons. Our technical colleges to-day are admirably fitted to turn out men who are well grounded in the fundamentals of engineering. As a rule they are good mathematicians, electricians, chemists, and physicists, and have all the technical knowledge necessary for pursuing the profession, but they are as a class woefully lacking in that they have no comprehension whatever of many of the subjects which are inseparably connected with the practice of the profession.

I believe that much of the manual training, which

now occupies such a large proportion of the "actual hours' work" in the courses of most technical colleges, could be replaced with profit by lectures on subjects related to those which have been mentioned in this paper.

No attempt has been made within this short paper to more than touch what has appealed to the writer as being the more important and most noticeable qualities lacking in the mental equipment of the average technical graduate with whom he comes in contact.

PRESIDENT SCOTT.—I think that we are all ready to admit that in the very great changes that have taken place in education during the last ten or fifteen years, the change in industrial, or more particularly, engineering, education is in the lead; that the evolution in engineering education has been the great evolution in modern educational methods. The growth of engineering colleges and of engineering courses has been phenomenal, but students have come faster than the equipment and the facilities, and notwithstanding the size of the graduating classes, they are still inadequate to meet the growing demands for educated engineers. The conditions now in active life and practical work for the engineer, the demands of engineering work and the place it has taken, mark, it seems to me, a new order of things in modern society. In the three papers that we have just heard, coming from men who deal with engineers, I have been struck with the fact that all of them call for breadth. They want engineers who are broad men; they call for quality of work in college, and not quantity; they call for discipline, for mental training to give the ability to take up and handle new problems;

and I also remarked in all the papers, some of them omitting entirely reference to shop work, the practical side, what we have been pleased to consider a valuable part of modern education in engineering—some papers omitted entirely the shop training, others referred to it asking that there be less of it and more of something else; less specific, more general. These three papers are open for discussion.

PRESIDENT WOODWARD.—Mr. President, I would like to say just a word. It goes without saying that these papers from practical men are a part of the proceedings of the Society for the Promotion of Engineering Education, and we want them all in our report. They contain exceedingly valuable suggestions from men who know and men who do things, and to some of us who have spent our lives in educating engineers they are exceedingly interesting. I would say that some of these points have been discussed in our Society, and I do not rise to discuss the papers, Mr. President, but simply to express my desire that they should be in print on our proceedings, so that every professor in the land may have a chance to see what these practical men think, to see where they put the emphasis; and it is very interesting to us. If we could draw a curve here representing the emphatic points in every man's paper, we should see where they accumulate occasionally and where they return to mediocrity; but they all put the emphasis on certain points, and those are the points that the professors of engineering ought to know. I am very glad to get these things. I think it is a very valuable contribution, and in the next paper which will follow after the discussion, we will have some points in regard to a course.

PROFESSOR GOLDSBOROUGH.—Mr. President, I have listened to the three papers with a great deal of interest, and I should like to discuss them in order, taking Mr. Gherardi's paper first, then Mr. Osborne's paper, and lastly Mr. White's paper.

I am not prepared to admit that the practical men always tell us what we want to know, and what they should tell us if they properly appreciated the conditions. The educators of the country have worked hard and have worked well to provide engineering courses that would meet the demands of practical engineering, and they have done it. How have they done it? Why have they done it? How do we know they have done it? Because the boys graduate, go out into practical life and do not fall down. That is the measure. They do not fall down. How do we know that they do not fall down? Why, the very men who have been reading us these papers, and who are examples of success in engineering life and practice, have had the same test that all the others have had, the only difference being that since their day the test has improved, and it has improved mightily. I know it. Why? Because I had the inferior test myself; and so I say that until the engineers get to the point where they are willing to accept our criticism on the way in which they do their work, they should not be too quick to criticise the way in which we do our work.

Now, to refer to some of the points made—Mr. Gherardi has taken up the matter of telling us what we should give the telephone engineering students to do. During the last few years I have been working on a course for telephone engineers, which is not published

in the catalogue of Purdue University, and what is the result of that course? I have talked to every engineer of prominence in the Bell Telephone Company, including Mr. Gherardi himself. I have talked with every prominent telephone engineer in the telephone business in the independent field. I have talked with the managers of those plants, with the presidents of the plants, not one, but for two years, conscientiously; I have gone among them, and this course that we give you is what they said they wanted, and nothing else. It is not a professor's idea. I would not claim that much of it (snapping his fingers). It is not my idea at all. It is their idea, and they are getting it, and it is being administered by a practical man, a man who was taken right out of the field, and some of the telephone people are mighty anxious lest he will tell those students something that they really do not want them to know. They think he knows too much about telephone engineering, that he is going to give them more of the practical than they want given out. That is what they are doing. And I claim that when we present these engineering problems from the educational standpoint, they should tell us not only what to teach the boys—we know that pretty well—but tell us what to do for the boys after they have graduated, tell them how they should make a success in life. They say they should be broad-minded men, should understand how to deal with labor. Very good. Not one of them has stated that the most important element in a young man's education is military discipline, military drill. That is the keynote very largely of the whole thing, to learn how to obey orders, to learn, when a man says three words, to do a whole lot.

is what we need to know; and to learn how, when you say three words, to make five hundred men do it, and have them understand that those three words are more than a volume. That is what the boys need. Four years of military training in school and a few years more in the National Guard have given me, I believe, more hold on my students than any other one thing that I have ever done. It is not necessary to have rules in college to make boys behave. Do not say anything. Keep still. Have them wondering what it is you are thinking about, and there will be an all-pervading silence.

Now, Mr. Gherardi has told us what we should give the men in telephone engineering; that they should have all that electrical engineers now have, and then that they should have a whole lot more besides. And he has not told us where the time for all that is coming from. He has not told us that the young men of this country who are growing up and who are going to be the bone and sinew of the engineering profession, are young men without financial means. They are not the fellows who have been brought up in rich families. They are the young men whose fathers cannot speak English and whose mothers have no conception of what it is, and they come right out of the backwoods; they have no advantages, but they persevere, and they materialize, and they are put in charge of the most important work of these big companies, spelling or no spelling, English or no English. Some of them are horrible examples. One of my men, who is with the Westinghouse Company to-day, used the worst English I ever heard in my life. If any one thinks I have not

a keen appreciation of the fact that the average graduate is deficient in English, he is very foolish. He has no knowledge of English, and it is going to take him ten or fifteen years before he gets it. But what else has he? He is a good engineer; he is going to make his way; he is earnest, persevering; he is going to turn out all right, and I will back him to the limit; and he will learn English too. It will take time, but he will do it. And how will he do it? He will do it because he has been stimulated to write papers for the American Institute of Electrical Engineers, to take part in discussions whenever he gets a chance in the towns and cities where he may happen to be. If you come to Niagara Falls and ride about in a cab without looking out of the window, then take a train and go away again, you have no conception of how to get about this city; but if you come here and walk about, observe as you go, when you get through you will understand. Why? Because there has been a mental impression made there; and in order to make a boy who is deficient in English understand what is right, you must get him to working at English, not because anybody tells him to, but because he takes a delight in it, sees the value of it, and because he knows that good papers on engineering subjects given before this Institute make him an engineer; ten years, and he is an engineer that every engineer in this world will shake hands with. That is what we want to tell the boys. We want them to feel that they must not sit down in an office when they go out, that they must not allow any man to tie them in the work of his business in such a way that they are going to be held there; that they must not work for a

man who says: "Work eight, or ten, or twelve hours a day for me, but it is all mine; you have no right to say a word about it." There is a good deal of that in practical life. Men are cranks. So I say the thing for our boys when they graduate is to be given a chance to work into the field of engineering, to be encouraged by their employers, as I am very glad to say a number of large companies are now doing, to be encouraged to prepare work, to prepare papers, to broaden themselves. It is impossible in four years for us to make an engineer who is forty-five years old with all the experience of twenty years in actual work, and it must not be expected.

Now, as to the best training for a business man. It is not the literary training. The best training, in my judgment, that exists to-day for a business man is the engineering training, because it comes more nearly up to the standard of meeting commercial requirements. We may have in a few years a good course which will embody commercial business engineering. I say "business engineering" for the reason that all of the great work of the future is going to be very largely engineering of one kind or another.

Professor Jacoby.—Mr. President, it may be a matter of interest to some of the practicing engineers, if they have not followed closely the recent developments in our courses of instruction, that in several of our institutions of learning courses are suggested by which the student may obtain both college course and engineering course in six years by properly electing the work in physics, chemistry, geology, and other subjects, in such a way that when he gets his degree of B.A. at

the end of four years, he will then be in a position to start right in at the beginning of the junior year and complete in two years the engineering course and have all that is required in both.

Mr. Ganz.—I feel it my duty, Mr. President, to say in reply to Mr. Osborne's paper that at the Stevens Institute of Technology last year a department of business engineering was inaugurated by the president, Mr. Alexander C. Humphreys, and during the past year two lectures a week were given the seniors on matters of shop accounting, depreciation, statistics, laws of contracts, etc. The value of this business training is well recognized at the Stevens Institute of Technology, and we would like to do more of it but we have not the time. Our curriculum is full. Every hour that is available is taken, and we are doing all that we can do.

In reply to Mr. White's paper, and the suggestion that English could be taught to good advantage in the shape of requiring reports from the students on laboratory work and other matters, I would like to say that to make these reports valuable, it is necessary that they should be very carefully corrected by the instructors, both for technical matter and for their English, handed back, and rewritten by the student, handed in again, and this process continued if necessary until the report is thoroughly satisfactory in every respect. Unless that is done the work of writing reports is of no value. With the large classes that we have to deal with nowadays, that is not an easy matter. We are doing some of it, we hope to do more, but, as I said before, the time is limited in our course.

Another feature which we have introduced, and

which brings the students closely in contact with practical matters, is to take them on inspection trips, take them out into the shops and show them how the work is done there. I take my senior class every spring on a ten days' trip, go to the Westinghouse works, the General Electric Works, railroad shops, and come to Niagara, and the students get a grasp of what is required of them in that way, I believe. To make these trips of real value, however, it is also necessary in my opinion to give lectures beforehand, as I do, illustrating them with lantern slides, so that when a student sees a machine in the power house he knows how it is made; when he goes down and sees the outside of a turbine wheel, he knows how it is constructed. I think that kind of work is very important and brings the student as near practice as we can ever hope to bring him in a technical school.

Professor Caldwell.—I very greatly appreciate these papers by practical men upon the question of engineering education. For the most part I do not think that the views expressed differ very widely from those held by engineering professors, but they are certainly of great value to us to use with our students as evidence of the needs of the practical man.

The student is very apt to take the view that the details are the important things, and he is inclined to feel that he is being defrauded if he gets a large amount of this more general training, and to be able to point to these papers as evidence of the importance of that class of work is very valuable. I wish, however, to insist that the great difficulty that presents itself to the engineering professor is not what things would be desirable

in the course, but what things should be left out of the course in order to get these other desirable things in. I wish that practical engineers who give us such papers as this would give us some views on that subject. It does very little good to tell us that it would be desirable to have all these additional subjects. We know most of that already ourselves. But we do not know what to leave out or what to condense in order to put these subjects in. We do not feel that the practical engineer would be satisfied, so far as we know, to have us leave out anything that we are giving now. To be sure, the subject of manual training has been mentioned, and it has been suggested that that might be cut down. In some institutions that may be so, but in many of the engineering colleges the manual training in shop work is at present reduced to what seems to be a minimum, just so that the students will have an idea of the use of tools and how they are to be applied in carrying on engineering work.

Professor Diemer.—I wish to confine my few remarks to Mr. Osborne's paper only. It has for some years seemed to me that we needed in the shop work in our colleges, an opportunity for giving the students more in the way of a careful study of sequences, of variations, of cuts, of speeds and of the best adaptation of tools to a specific work. It seems to me that the introduction of this work is so important that it should be taught, even if it required the laying out of a smaller number of distinct shop exercises. Another point, in my own experience in teaching machine design to mechanical engineers, is to require the students to prepare a complete bill of material of the parts, together with an

estimate of cost of material, and a discussion of the details and processes required in turning out the design. With regard to the question of shop accounting and questions having to do with methods of compensating labor, I believe that at the present day the mechanical engineering departments of a number of our leading institutions offer courses in this work, calling them sometimes by the name of "factory organization," sometimes "factory system," sometimes "shop economics." I have for several years given a full term's course in this work, which involved considerable collateral reading of English literature by the students, covering five hours per week. It seems very desirable that students in electrical engineering should also join in such classes, since so large a number of the men, according to Mr. Osborne, will be engaged in the manufacturing branch of the electrical field. This fact is too often not realized by the students themselves. We all know that a student, upon graduation, seems very much disappointed if he doesn't get immediately into the field of testing or designing. The writer has advocated, in addition to the methods of solving the problem that Mr. Osborne has proposed, that we give the students training in factory accounting.

Professor Allen.—Mr. President, I wish in the first place to express my appreciation, not only of the papers that are presented by the men in practice, but also my appreciation of the way in which those papers are presented. I do not feel, as I think Professor Goldsborough may, that those papers are unfair or that they attack the engineering professor. If I understand it, these gentlemen were asked to present their views as to

what is desirable in an engineering graduate. I do not understand that they were asked to state what should be put into the courses. They state what is desirable, for our consideration, and with the hope and expectation that teachers of engineering will take to heart everything that they say, and so far as possible bring about the results that to them seem desirable. I must confess that I have been very much pleased by the temper, if you please to put it that way, of the papers that have been presented. I think, however, that the views presented are in cases liable to be misleading as to the propriety of the introduction of certain lines of study; and, to be as brief as I can, I should like to state what I think is the problem of the educator with relation to the student. It is impossible that our engineering colleges should make a finished engineer; there is not time. An engineering college does not have the facilities or the opportunities for doing all that is necessary to make the successful engineer. I have in mind the element of experience. The college is not in a position, either in the way of outfit or in many other ways, to give to the young engineer, or the young man who will become an engineer, the experience that is necessary to his success. If our engineering colleges attempted that, they would be a failure; the men would go into practical work instead of going to college, for the purpose of gaining experience. There is left, then, for the college, the obligation to provide the student with the proper theory, and to that work the college must be devoted at all hazards. But proper theory cannot be given unless it is united with applications, or what you may call experience, and the college graduate

does, as a matter of necessity, if he acquires proper theoretical knowledge, acquire quite a little of experience. It is necessary, beyond this, that he acquire enough experience so that he will be valuable to the man who employs him, so that he shall be in the way of gaining further experience. But the engineering college cannot, it should not, expect to go beyond these two points, I believe, in providing the element of experience: so much as is necessary to give point to theory; so much as is necessary to put the student graduate in the way of gathering the larger experience which shall make him a complete and valuable engineer.

I suspect that the manufacturer—and I have in mind Mr. Osborne's paper, and I think my point of view may be quite different from his in this matter—I suspect that the manufacturer is oftentimes disposed to expect too much of the colleges. If there are these two things to be done for the engineer, who shall do the work? The college will do part. It cannot do all. The manufacturer with his physical material expects to receive it in a certain condition; and to put additional work on it before he allows it to depart from his works. I believe the manufacturer should do more. Part of his outfit is the young engineer. I believe he should put some work on the young engineer. The matter of accounting has been given as much attention as any other single subject of discussion in the proceedings of our Society for the Promotion of Engineering Education. That that is valuable and necessary for the successful administration of manufacturing enterprises goes without saying. But where shall the work be done? Are there facilities existing in the college of engineering to

take up that work to the best advantage? Should not the manufacturer consider it a part of his duty to take the engineering graduate who is turned over to him and to educate him in matters of that kind, in the regular manufactory, which is a laboratory of accounts, if you please, where the work can be done better than it can in the college of engineering? Without feeling at all positive on that point, my impression is that that is the work that the manufacturer should expect to do in producing the engineer whom he wishes to use. The college and the manufactory, each, should do the part of the work that it is best capable of doing.

PROFESSOR C. A. WALDO.—Mr. President, if Mr. White will excuse me, I would like to ask him why he retains Latin in his typical course for an engineer.

MR. WHITE.—I think, Mr. President, that most of the papers have shown that those of us who have gone into professional life appreciate that the great problem, perhaps, for the educator to solve, is how to do ten years' work in four years, and how he can get in the limited time a fair general training in the ability to learn, and some specific knowledge of particular subjects. As to the suggestions made, I would not presume to attempt to dictate, or even to suggest, specifically to the educator, but I thought it would do no harm to indicate in a general way some of the points which it seemed to us might have preference over some other points, which are also important, but relatively, from our point of view, less important. The study of Latin was not included with those which were considered as of primary importance, but it would be perhaps in the secondary or tertiary list. It seems to me that

students can decide on the amount of time available, and if they can take only the primary, it would perhaps be better to omit the secondary and tertiary, omit Latin and French entirely and concentrate the time on some of the more important—physics, mechanics, chemistry, and those fundamental engineering studies.

Professor Goldsborough.—I want to say, Mr. President, that I do not feel that one word of criticism of the teachers has been voiced in any one of the three papers, and if my remarks led any one to feel that I had that idea, I wish now to say pointedly that such is not the case. I think that the tone of the papers, the way in which they are presented and in which the whole matter has been handled, is one that is very complimentary to the engineering teachers and to the engineering courses, because they have said that what we are giving the men is right, only that we do not give them enough of it. The point that I want to bring out is that in the papers on education which the practical men have given us in the last few years, they have not taken the student from the time he graduates and outlined a course for him up through his engineering life. Now, if the practical men will outline and tell the course that the men are put through after they graduate, what is demanded of them and the order in which it is demanded, and the attitude that we should have the student hold toward his future engineering work, then they will be giving us something that we very much want to know. Mr. White's paper gives us a great deal of that, more than any of the other papers, and had time permitted I would have arrived at that point and enlarged upon the fact that I think Mr. White's paper has given

us a good deal that is of value in showing the teachers what they must develop their boys for.

PROFESSOR RAYMOND.—I think Mr. White has pretty nearly hit the nail on the head when he says that the problem before us is how to put ten years' work into four. I think we have very nearly solved that problem perhaps, and it seems to me the solution is this—that the student shall take perhaps three to four years in the arts course, two to three years more in the engineering college and the balance of the time in business, and that then, if he has it in him, he will perhaps be ready to take the position of responsibility that we hope they all may secure, and which it is absolutely impossible that they all shall secure.

It is evident that we have been listening to the cream of the product of the universities of some twenty-five to forty years ago, and after making all due allowance for that, I am rather tempted to ask, with Professor Goldsborough, where did these people get the training that has put them in the positions that they are now occupying?

PROFESSOR CARHART.—I should like, Mr. President, to call attention briefly to another phase of engineering education which has not been alluded to directly. It seems to me that the differentiation in engineering training in the colleges should come in practice, after the man is through with the technical colleges. And I have a few times made a suggestion, personally and privately, which I am going to repeat, and which has met, I think, with considerable favor from engineers. It is evident that more time is needed for the training of the engineer. It has been my practice in

the little work that I have done in engineering education, to insist upon it that we should teach principles, with enough of the laboratory or the shop, as has been said, to give point to those principles, to connect them with real practical affairs, and not to let the laboratory or the shop encroach upon the valuable time of the student further than this; and I have been greatly gratified when our students have returned, after one or more years' experience outside, to have them say of their own accord that this plan is right, that they can get more experience in practical affairs in six weeks in a large manufacturing establishment than they could get in college in four years. The point I wish to make is this, that instead of trying to make a complete mechanical, civil, electrical, marine, telegraph, telephone, or any other sort of engineer in a training school, we should arrange the courses if possible so as to make an engineer. Let him apply the adjective after he gets into his practical experience. In other words, it seems to me that it should be the effort to lay a broad foundation in those subjects which the engineer must have to build upon. Now, you are perfectly well aware of the fact that a man graduates as a mechanical engineer and goes out and practices electrical engineering; graduates as a civil engineer, or in the civil engineering course, and goes out and practices electrical engineering, and so on around the whole series. In other words, it is almost never possible to tell during a man's college course in what field he is going to work when he gets through. So that if we could return to the old practice of military and civil engineering, as you are well aware, make engineers

of one or the other of those divisions, and have a five-year course in which to do it, under the high pressure which seems to be coming into vogue now for all sorts of transmission of energy, possibly we could put into the course what would satisfy everybody.

President Scott.—In connection with your discussion, Professor Carhart, I would like to call attention to one sentence in Mr. Osborne's paper, that in which he says that probably only one tenth of the engineering graduates go into engineering pure and simple, and the other nine tenths into allied industries and executive positions, while on the other hand the courses which these men have followed have generally not pretended or considered any other probability than that they would become engineers pure and simple. Your discussion, I think, was with regard to engineers pure and simple. You dealt with that one tenth and not with the other nine tenths.

Professor Carhart.—May I just add a single sentence then, to this effect, that if only one tenth of the students who pass through engineering schools become engineers, it is evident there is something wrong either with the raw material we get or with the instruction we give them.

President Scott.—Or is it not that there is a demand for engineering in the broader sense, that engineering training is useful in other lines of activity than pure engineering?

Professor Carhart.—Oh, yes, that is so.

President Scott.—And yet our education is for the pure engineer.

Mr. Rushmore.—One would wish very much before

saying anything to so honorable a body as this to have some ultimate conclusions to present. It was Theodore Roosevelt who said, "We often, in order to reach the end, have to lose something in the form," and so my remarks are from the standpoint of a man working in an engineering office who has lately had to look over a great many possibilities to find people to help him carry out his ideas. I have just put a few points down here, and I am going to offer them simply as my own, though I hesitate very much in speaking before an audience of college professors like this, and anything I say should be taken as representing only my own views on the subject. There was an excellent little thing gotten out by the New York Central Railroad several years ago which to my mind describes what we need to aim at in engineering. I do not remember what this little article was called, but during the Spanish War our government desired to communicate with the insurgents in Cuba, and one of the officers of our army was called to Washington, handed the message and told to take that to a certain officer of the insurgents. That was all. Where the man was he did not know, or how to get there. He didn't ask. He had to look that all up for himself. To obey was all that he knew. I never thought so much of it until I got into a position where I had something of the same conditions. In my own relations with others, what I want is simply a man with whom I can talk over the object I want to attain, and then help him all I can, but that is all. I want him to carry out the rest of it. And so I want to run over this as hastily as I can.

The principal thing I would regard in an engineer is

not so much the information he has, but what he is in himself, his ability to go ahead, and above all things, accuracy; because if the information he gives is not accurate it is not worth having. He ought also to have the faculty of observation so as to learn to work quickly. He ought also to be able to find out what the results that he gets, indicate; to be able to find out what the exponent of variation is, if he is testing iron loss curves; and I may say here that I have been working a long while to find out accurately the iron loss of armatures, and I do not know how many men I have put at that work, perhaps as many as eight, and at the end I had one man who got accurate results. It was almost hopeless.

There is one thing which I believe, which probably will be opposed to the ideas possessed by nearly all of you—that in the four years' work which a man does before he goes out into the world, there are a great many hours out of which he does not get as much as he ought to; at least I feel that that was my experience—where the professor was giving out information and I sat there putting down the headings, afterward went home and wrote it up and tried to think what I had left out, or what his idea was on the subject. I felt that those hours were almost completely thrown away, and for myself I do not believe in that method of instruction. The ideas we want in an engineering office are very few of them of first importance. The people of this country are too much occupied, there is too much concentration, for it to be taught in the college; a man ought to be able to get it at other times. My idea therefore would be, instead of teaching a man all the small things that he might want outside, to give him a strong

basis in the fundamental principles, because he will get the rest afterward.

PROFESSOR J. P. JACKSON.—I would like to say one or two words upon these papers, Mr. President, to indicate, first, my great pleasure in not being disagreeably surprised. Last night in our meeting one of the practical engineers, and a very successful engineer, pitched into us very severely—that is, into the educational men, and we were rather afraid we might be caused to suffer to-day; but the papers dealt with the subject in such a careful manner that I think every professor or college man here has reason to feel that the authors knew what they were talking about and were saying what they could for the best interests of our own work. I do not know whether I can say that the men who wrote the papers to-day are the thinking minds of the present decade or not, but it seems as though they are. John Milton, as I said in my paper the other day in another society, said that education was to prepare you "for life in the court, in the counting room, in all the work, walks, and ways of life, either civil or military," or about that, and Lord Chesterfield said something of the same kind. Coming down later, Herbert Spencer said something more of the same kind, and these are the great men to whom we refer to get ideas. Mr. White has just said the same thing this morning, and I suppose we will therefore have to put him in the same class. But I want to say this, that the ideal method of education, I believe—so considered among engineers—is to give them a good four years' high school or academy course, with a general training in the three fundamentals, which are English, or language, history,

etc.; mathematics; physical sciences, which include chemistry and matters of that kind; give them a college course which runs along in the same way but specializes, possibly, a little, and then give them a post-graduate course of a very small amount of time —having taken eight years before, two years, possibly, of this specialized work would be sufficient. But our boys are poor, and up to the present time very few can afford to take this extra time. I believe every boy ought to take it, and if I ever have a son it shall be my desire to have him take such a course. But I want to make this suggestion—Mr. White employs college graduates, he evidently believes in them, and Mr. Gherardi does the same, Mr. Osborne does the same, in large numbers—now, if they will make some distinction and offer a little greater inducements or request a little more carefully that their men have this broader and longer education. I believe that more of the young men will feel that they will be able to take such an extended course, and it will have a tendency to uplift the whole scheme of education.

Professor Kent.—The criticism made by Mr. Osborne is the same that we have heard for the last twenty-five years; that is, a criticism of the college graduate because he doesn't know enough. The college graduate should be differentiated from the post-graduate. That is, the one who is just freshly out of college does not know a great deal as compared to the man who takes a post-graduate course in the works "in overalls and grease," I believe the expression is. I do not think the criticisms Mr. Osborne makes will hold as to that class of grad-

uates, that have taken five years' shop experience after graduation and have specialized in telephony, business, engineering accounting, or some other branch. I do not believe that these criticisms apply to that kind of graduates. Now, the requirements for an engineer—not an engineering student, but an engineer—which are laid down in Mr. Osborne's paper are the requirements of a man not less than forty years of age, with an experience of at least fifteen years after he is graduated.

President Scott.—Mr. Osborne will not have attained that age himself for four or five years.

Professor Kent.—Well, he is asking for more than he has himself then, in these graduates; so that we must not expect too much from these immature minds, the recent college graduates. What he does get is the training which qualifies him to take this post-graduate course "in overalls and grease," and finally get what Mr. Osborne wants.

Professor D. C. Jackson.—Mr. President, I have no discussion to offer upon these papers, because my paper was most complimentary, and after what my little brother (Professor J. P. Jackson) has said, I am ashamed to make any remark. But what I want to do, is to put on record in the American Institute of Electrical Engineers the fact that there are some of us that are associated with strong engineering schools who are too old-fashioned to agree with the radicalism of Professor Franklin and Professor Goldsborough. There is no more ardent opponent of the spectacular in the teaching of physics and engineering than I am, but at the same time it is certainly of advantage, as is shown by my experience, and I am sure could be

shown by the experience of any other who follows the profession carefully—it is certainly of advantage to call the student's attention to the wonder of the great unity, the great continuity and the extreme persistence of nature and the way in which nature's laws are always fulfilled. With most other views of Professor Franklin's paper, which of course is not under discussion now, I agree.

Now, with reference to Professor Goldsborough's reaction, while there is a reaction from a good many of the abuses that engineering schools in the past have suffered to creep in. He is going too far in respect to his radicalism, which is, for instance, illustrated by his description of the course in telephone engineering. I am quite sure that in the college that I am connected with we prepare men for telephone engineering in just as substantial and satisfactory a way as they do at Purdue, by teaching them principles, principles, principles, and the way in which those principles may be applied; and I feel confident—of course I have not been at it long enough, and Professor Goldsborough has not been at it long enough, to demonstrate either of our ways—perhaps he is just as competent as I am—but I feel confident that our method will redound to the ultimate advantage of our graduates to a greater degree than the method which deals more distinctly with the technical details that may be learned after a man leaves college, and I appeal for the substantiation of my position to the best writings of the best minds on pedagogical and teaching subjects.

President Scott.—I would like to close the discussion—our time is getting on. I will allow myself,

however, the privilege of saying two words. First, they have had in Mr. Osborne's company, largely through Mr. Osborne's own arrangement, an apprenticeship course of a couple of years through different departments of the manufactory, assigned to students who go there. More than that, there is an electrical club organized, with lectures and little engineering society meetings among the students, so that the work is going along progressively, and they meet and hear lectures on these general subjects from the officers of the company.

Second, in order to get the college student in touch with electrical engineering work, the American Institute of Electrical Engineers has formed local branches. In the little booklets which are here, which you are welcome to, you will find in the back part a directory of local branches. You will find a dozen or more of those in a number of the principal colleges. Professors Jackson, Goldsborough, and probably a dozen others who are here, have them in their colleges, where these young men take the papers of the American Institute each month, read them over in a little society of their own and discuss them, these papers often dealing with the electrical problems of the present, and in that way the students are getting in touch with what is going on, not so much from the information in the papers, but from the interest which they are getting in the work, this being the great aim.

We will now have about a three minutes' recess, after which the meeting will be turned over to the Society for the Promotion of Engineering Education.

(After Recess.)

President C. M. Woodward in the chair.

President Woodward.—The Society for the Promotion of Engineering Education expected to present two papers to-day, but I am informed just now by Professor Owens that his paper is not fully prepared and that he cannot give it this morning. He, however, will complete it and present it to the secretaries of the two societies so that it may appear in our Proceedings unless you object. The subject is "Laboratory Work, Shop Methods and Practice in Typical Electrical Engineering Courses." Professor Owens is professor of electrical engineering at McGill University.

The paper which I now have the pleasure of calling for, is one by Professor D. C. Jackson, of the University of Wisconsin.

THE TYPICAL COLLEGE COURSES DEALING WITH THE PROFESSIONAL AND THEORETICAL PHASES OF ELECTRICAL ENGINEERING.

BY DUGALD C. JACKSON,

Professor of Electrical Engineering, University of Wisconsin.

At the Chicago meeting of the American Institute of Electrical Engineers held eleven years ago, I presented a paper relating to the subject now under discussion. The proposed subject then apparently created some consternation amongst the members of the committee on papers, who seemed to fear that it was not of sufficient interest to the Society. The old prejudice still held against "college men" in the minds of so-called "practical men" who had grown influential in engineering practice without having had experience of college life and training. Happily the foundation for this prejudice has ere this been destroyed through the influence of the industrial results achieved by college men. The old prejudice, so far as it now exists, has more particularly drifted into the way of criticism of the engineering colleges rather than of their graduates, and the character of the schools and the training they afford are subjects of eager discussion in engineering circles.

This extended interest now manifested in the work of the engineering colleges produces a situation which may be of great usefulness to the schools. The character of a college is that which its alumni determines,

and any engineering college may be improved by thoughtful suggestions and broadly considered criticisms emanating from its alumni and others who have its best interests at heart.

Two fundamental propositions must be held clearly in view in all such criticisms, if they are to be of service to the educational administration of the engineering colleges:

1. That it is the business of these colleges to train young men into fertile and exact thinkers guided by common sense, who have a profound knowledge of natural laws and the means for utilizing natural forces for the advantage of man. In other words, it is the business of the engineering colleges to produce, not finished engineers, but young men with a great capacity for becoming engineers, the goal being obtained by the graduate only after years of development in the school of life.

2. The problem to be met by the engineering colleges is more particularly a problem in *how to properly train* to the stated purpose. The names attached to the subjects taught are not so important as the results produced by the teaching, namely, the effect impressed on the students' powers. This is a teacher's problem —a question of pedagogy, rather than of the engineering profession. It must be met with all the directness and power of the engineer's best efforts, but it cannot be solved as solely relating to the engineering profession. Much error on this point lies in the minds of many who assume the part of critics of the curricula of the engineering schools.

In this connection I may be permitted to point out

that proposals set up as apparently new in the presidential address one year ago, by President Steinmetz of the American Institute of Electrical Engineers, have for many years been largely included within the ideals of numerous American colleges of engineering. It must be admitted that only few of the engineering colleges are living up to their better ideals. This is partially due, on the one hand, to personal or institutional ambitions which foster the sensational or spectacular and thereby inevitably ruin good teaching, and on the other hand, to the meager support both in encouragement and funds which I have noticed is the lot of the engineering colleges attached to many universities. The latter, like the former, is often the result of personal prejudices or ambitions.

Most of the faults which are so trenchantly and indiscriminately charged to engineering colleges by many engineers, should, so far as they are real, be laid to the pedagogical inexperience and faulty ambitions of the authorities of the many colleges; and exception should be made of the few in the first rank, in which it is safe to say, the ideals are high and well centered, and the administrative organizations hold the ideals continuously in view.

The query here naturally arises: Of what do these ideals properly consist and how fairly should they be met by the college before its course in electrical engineering may be approved as of first rank? Electrical engineering demands industrial engineers—men with an industrial training of the highest type, competent to conceive, organize and direct extended industrial enterprises of broadly varied character. For the highest

success, these men must be keen, straightforward thinkers who see things as they are and are not to be misled by fancies; they must have an extended, and even profound, knowledge of natural laws (more particularly of those relating to energy which rest on the law of the conservation of energy), an extended knowledge of the useful applications of these laws, and an instinctive capacity for reasoning straight from cause to effect. Moreover, they must know men and the affairs of men, which is sociology; and they must be acquainted with business methods and the affairs of the business world. Briefly, to reach his highest influence, each man must combine in one, a man in the physical sciences, a man in sociology, and a man of business. All engineers cannot reach this high mark, but the engineering college course should start each one of its students toward that degree of attainment which his individual powers will permit.

Michael Faraday (whose conservatism and intellectual clearness are proverbial) said that it requires twenty years to "make a man" in the physical sciences. The engineering school must put each student in the way of becoming, so far as his mental and physical powers warrant, not only a man in the physical sciences, but a man in sociology and a man in business as well; and this must be done within the narrow limits of four years. It is clear that only the foundations of "the man" may be laid in the prescribed time, and the engineering college must, therefore, rigorously hold itself to the fundamentals. The engineering college faculty which is contented to deal out so-called "information courses" on the narrowly em-

pirical side of engineering practice, deals a wrong to its students which they may not recognize at the moment but which will ultimately tell heavily against their success.

The students that enter the engineering schools of the West, and I presume likewise of the East, are from amongst the most vigorous minds of the high schools and the preparatory schools; and yet it must be admitted that they ordinarily possess little power of clear thinking, power of initiative, regard for accuracy, or understanding of continuous and severe intellectual effort, as these important attributes are understood in industrial circles. They are not yet mature in body and are less mature in mind (the latter being, I think, in accord with the natural order of development). But they commonly are well equipped with physical vigor and latent mental strength. Their preparatory schooling has given them a defective acquaintance with the construction of the English language and the spelling of English words, a still more defective acquaintance with French or German or a fairly good grounding in elementary Latin, a smattering of civics and history, a training in the elementary principles of arithmetic, geometry and algebra, from which the factor of accuracy in application has often been omitted, and perhaps an enthusiastic interest in the physical sciences.

This enumeration of the attainments of the students entering the engineering colleges may perhaps be interpreted as reflecting on the secondary school teachers, but I wish vigorously to deny the validity of any such interpretation. I can truthfully say that, considering all of the conditions, there is no more painstaking and right-wishing body of people than these teachers.

Many of the faults in the preparatory training of our engineering college students are caused by a doubt which is now apparently agitating educational circles on account of the question whether the high schools shall be the "people's colleges" or remain in the station of secondary or "preparatory" schools. This doubt is apparently not yet resolved in the minds of the moulders of educational thought; but the traditional old-time secondary school training which produced men who could spell and cipher and who had received a thorough and accurate drill in the details of at least one language, is certainly to be preferred as a preparation for an engineering college course. In my own estimation, when accompanied with history and a year spent in civics and natural science, it is not only to be preferred as a school course for preparing the student for college, but also as a course for those numerous students who cannot go through college.

Taking the students as they come and may be expected to come for the present, the electrical engineering course must include the following branches of learning which are preparatory to the more strictly professional studies:

1. That fuller training in the construction of the English language which is requisite to clear thinking and clear writing, preferably accompanied by an additional language for added strength.

2. The collateral part of expression in drawing.

3. Mathematics through an appropriate amount of calculus including the integration and solution of equations involving derivatives and instruction in the use of coplanar vectors, and perhaps quaternion quan-

tities, all of which should be taught as applied logic with special emphasis laid on interpreting the meaning of equations.

4. The science of chemistry, soundly taught.

5. The science of physics soundly taught, with particular emphasis laid on the elementary mechanics.

6. Applied mechanics.

Mechanics—the philosophy of matter, force and energy—is the backbone of the electrical engineer's college training.

Instruction in the science branches should be accompanied by well-conceived and properly conducted laboratory work mostly of quantitative character, accompanying and illustrating the class-room instruction; and all instruction, whether in natural science, mathematics or languages, should be under the direction of men who are engineers or in full sympathy with the aims and ideals of engineering.

A limited amount of manual training may well accompany these studies, and likewise, if time can be found for it without everburdening the reasonable physical powers of the student, a limited amount of proper instruction in surveying (including the use of the compass, transit, and level) will always prove a force for quickening the student's perceptions, and at the same time put him into possession of processes of probable future value.

In a few of our engineering colleges which rigidly demand the best preparatory work from the high schools, and which are, at the same time, best manned in their faculties, not less than two years are required to cover the ground above described, if the work is done

in a reasonably satisfactory manner. But the above ground cannot be covered with anything like reasonable success in much or any less than three years, in the larger number of engineering schools that are usually accorded high rank.

After covering these branches, it seems to be the tendency in many colleges to fly off into superficial or descriptive courses relating to engineering practice, during the remaining time of the allotted four years. This is especially apparent in those colleges where the faculties are ambitious to see their graduates take an immediate place of considerable responsibility in the world. This is a fault that destroys much of the ultimate advantage which the students may derive from their engineering course. It is a fault also, which casts just suspicion on engineering education alike in conservative academic circles and in well-informed industrial circles.

A resort to mainly descriptive courses of instruction during the latter portion of the students' life in college, largely neutralizes the advantage flowing from the instruction in the fundamentals heretofore described. The students must now be taught many things relating to engineering life. They must learn something regarding the forms and formalities relating to the affairs of business life. They must learn the characteristics and uses of materials, their correct application to the building of actual structures, the meaning of kinematics and the processes of designing and using real machinery. They must also learn to reason regarding the special principles of hydraulics and thermodynamics, and the way in which they enter into the design, con-

struction, and operation of machines, and the manner in which they modify the usefulness of machines and the efficiencies of numerous industrial enterprises. Again, they must learn to reason clearly and rationally in regard to the specific principles relating to applied electricity, including its widely diverse factors, and the way in which these principles enter into everyday practice. And they should learn something of the history of the development of engineering and of the lives of its great men, for the stirring of proper ambitions.

The electrical engineering department should be divided into not less than four subdivisions, comprising respectively: Applied electro-magnetism, which includes the principles relating to electro-magnetic machinery and apparatus; the theory and practice relating to alternating and variable currents, which include the principles connected with all those numerous phenomena which accompany variable current flow; applied electro-chemistry and electro-metallurgy; and electrical installations, which includes the applications in engineering practice of the numerous principles in the design, construction, operation, and testing of complete installations and the component parts thereof.

The teaching force of the department should afford a competent expert engineer for the head of each of these subdivisions, and such additional well-trained force as may be necessary to adequately carry on class-room and laboratory instruction for the particular number of undergraduate and advanced students which attend the college. The head of such a department should spend much of his time in supervising the teaching in class-rooms and laboratories which is performed by his various subordinates.

But through all of this professional instruction of the latter part of the course, it is still *principles, principles, principles,* and rational methods of reasoning which must be taught, if full justice is done the students, until each student becomes a man of open mind, keen observation, analytical thinking, and accurate powers of inference. This instruction should be kept close to the tenets of good practice, and the senses of the student should be constantly stimulated by illustrations and problems drawn from practice. The drill in reasoning can undoubtedly be best gained through rational instruction in the useful applications of scientific principles and laws; and no criticism can be justly passed even by the most conservative educational circles because the graduate is enabled to earn his living as a result of this training; but the purely descriptive should ordinarily be avoided except in a few cases where it has a specific function in improving the understanding of an application of principles or is adopted as a desirable auxiliary to stimulate the sustained interest of the students, and thus add vitality to the teaching. Indeed, except for the purposes here defined, the introduction of the purely descriptive into the electrical engineering course, wastes the students' time and injuries their training, thus abridging their prospects of ultimate breadth and power.

The typical courses in electrical engineering which are to-day advertised in college catalogues belong to three classes or combinations thereof. Only the third of these may be acknowledged to fairly meet the proper ideals in such a course. It is to be remembered that I speak of professional engineering. No one possesses

a fuller sympathy with the ideals of schools for training men for the mechanical trades short of engineering and bordering thereon, but these schools are not considered in my present discussion.

First, are courses in which predominate the old-time instruction in physics with far more to do with the illustration of the beauties of nature than with the great underlying natural laws. The teaching of mathematics, mechanics and like ground-work studies is not ordinarily well supervised in colleges that maintain such courses in electrical engineering, because the administrative authorities are out of touch with the industrial world and mistakenly put the superficial and spectacular in science into the place of that sound instruction only through which an engineering course may be rightly maintained. It is needless to add that the average graduate from courses of this type is ordinarily of less value in engineering than the average graduate from an old-time classical course where at least thoroughness is a requirement; and electrical engineering courses of this type are rapidly disappearing through a merging into one of the following types.

Second, are courses in which the ground-work studies (English, mathematics, chemistry, physics, mechanics) are perhaps reasonably well taught through the earlier years, but in which the latter part of the course is diverted to the training of inexperienced students for immediate ''jobs'' in which the students may find some responsibility and proportionate pay immediately after graduation. These courses do not teach engineering in the sound sense. They injure the future of the students by occupying time in teaching them handicrafts

in college which they could better learn in the factory or field, or in teaching empirical methods of practice which change almost before they can be put to useful account by the graduates.

The students in these courses frequently gain the impression that the highest type of engineering practice is no more than an advanced artisanship and that a graduate from the electrical engineering course is the equivalent of a journeyman. The most serious injury flows from this, through the undesirable narrowing of ideals and ambitions. This unfortunate result occurs the more readily because the popular usage of the word engineer makes it denote either an engine driver (a man of purely manual calling) or a man skilled in the principles and professional practice of engineering.

Third, are courses following the ideals which I have herein earlier described. Incompetent students who enter these courses are soon discouraged and drop out. Those whose calling is to artisanship go elsewhere either to a different school or directly to an apprenticeship. Those who complete the course, as a rule, are competent men; but they are not likely to enter immediately into positions of much responsibility, but rather to go into the so-called "cadet" positions or "student" positions of great industrial enterprises for the purpose of gaining that experience in the crafts which may enable them to make the most extended use of their training in principles. Here they gradually "find themselves" and ultimately reach the influence in the industrial world for which their caliber and training fits them. These men, if properly taught, have clean-cut ambitions and high ideals as well as the ability to

think well and do wisely. Their earnings, and perhaps their usefulness to their employers, may be not so great for a short interval as those of the men who are taught more of empiricism and artisanship and less of rational science during their college course, but the advantage soon flows in a strong current towards the scientifically trained.

The men who are responsible for this third type of electrical engineering courses may reasonably cry to be delivered from judgment upon the success of their work which is based on the average earnings of the graduates during their first year out of college. The medical schools and law schools are judged by the attainments of their graduates reached in a decade or even in a quarter of a century, and this also should be the basis upon which to judge the work of the electrical engineering courses of this third and highest type.

Do not believe for a moment, however, that I would teach all theory and no practice. The earlier parts of this paper prove the contrary. In truth, right theory and the best practice are one, and practice which is out of accord with right theory is mere rule of thumb and can be bettered. The best college course in electrical engineering is the one which so teaches the fundamentals that right theory may be fully grasped, and which constantly illustrates the bearing of theory by examples derived from good practice. The administration of such a course requires thoughtful, clear-headed men, who are acquainted with the principles and right practice of pedagogy as well as trained in the principles and experienced in the practice of engineering.

My discussion of the subject makes it clear that there

is a wide variance between the methods of the colleges which support electrical engineering courses. Complete unity is not only impossible but would undoubtedly be undesirable, since scope for individuality is as essential here as in the control of industrial enterprises; but the cause of sound college training for electrical engineers would be advanced by any action which clearly places the true aims of the college courses in electrical engineering before the authorities of all of our colleges which support such courses. And I may add that many of the greatest weaknesses of electrical engineering courses are due to the fact that the executive heads of colleges or universities do not always understand what engineering truly stands for, and they often have no fair conception of the soundness of training that is required for its practice.

President Woodward.—This, with the other papers we have had this morning will make a very admirable and supplementary discussion of this very interesting subject. The paper is now open for discussion.

Evidently the Society is indisposed to resume a discussion which has really been going on already this morning on the same subject, and would prefer to hear the other papers which have been prepared by the members of the other Society rather than to take longer with this. If that is your wish I will take the liberty of calling upon the next paper, number five, on the list, by Mr. Mullin.

President Scott in the chair.

TRAINING AN ARTIST IN THE FORCES OF NATURE.

BY E. H. MULLIN.

If we go back in the history of our language to the first known use of the word "education," we find that in 1540 it had as its meaning "the process of nourishing or rearing a child or young person." It will be noticed that in this case, as in so many others, a term which may now be regarded as meaning something abstract and psychological is derived by metaphorical extension from an earlier concrete and physical concept. Yet if the word "education" has gained in breadth since its first use four and a half centuries ago, it has also lost much in depth—at least as commonly used. The essence of the word "nourishing" is assimilation; it conveys the idea of the food which is most easily converted into life-giving blood, and thence, with hardly a pause, into nerves, bones, and muscles, to become an inseparable part of our bodies. For one reason or another, we seem to have passed beyond the stage of a simple educational diet which can be thoroughly assimilated; we present either the jaded palates of a worn-out race, or the capricious appetites of spoiled children. Instead of the education roast and boiled joints of our forefathers, we toy with highly seasoned entrées which blunt our appetites for the time being, but do not give us the strength for long fasts, the energy for great work, or the physical repose necessary for deep thought.

We shall find, if we keep the idea of assimilation as

the primary attribute of all education, that the physical and mental analogies are reasonably close and hardly, if at all, misleading. Mental indigestion from over-stuffing, no less than physical indigestion, produces cloudiness of the brain. Mental dyspepsia may follow a diet of too large a variety of elective courses, just as physical dyspepsia may follow over-indulgence in highly spiced but non-assimilative foods. In both cases time is an indispensable factor to assimilation; plain food will be most enduring in results; maximum efficiency will be found in maximum assimilation and minimum waste. Fixed habits are perhaps the most valuable gift we can receive, whether from home rearing, from college training, or from that first part of our lives passed in the world of men. Yet granted that we have taken a firm hold of essentials, we may pursue cognate non-essentials as an enlightening means of recreation. Every author has his historical background; every science has its borderland; every art has its path of development. Knowledge is the result of profound study; culture is the reward of diligent exploration. With knowledge alone we are as flatlanders, realizing our neighbors only when we touch them; by the aid of culture we can rise above our surroundings, and, by viewing the relation of our neighbors to each other, form a juster estimate of our relation to them.

For, in our realization of our true relationship to the whole of the outer world lies the benefit of our education. The pure specialist, without sympathy and without comprehension is simply a machine tool in the hands of a higher order of intelligence. When Mr. Carnegie claimed for himself only the power of acting

as a magnet for much abler men, he either meant much more than he said, or said much more than he meant. To utilize ability, to turn it into its proper channels, to mark the time and place when and where one kind of specialized mind should begin and where it should stop to allow the next specialized mind to take up the running, is the function of true greatness. The general in command of armies, the statesman responsible for a party, the captain of industry with success or failure hanging upon his decision, asks no more than that the subordinate whom he chooses can convert his ideas into action. "Be bold, be bold, be not too bold," said the ancient sage. "Specialize, specialize, but don't specialize too much," says the modern analogue.

Capital, modern economists are agreed, is the crystallized savings which can be lent out to reproduce itself in useful work. It is, in fact, stored energy. In its baldest form, capital represents the wheat saved from last year's crop to enable the laborer to garner next year's crop without dying of starvation while next year's crop is growing. In its broadest sense, education is not capital but tools. It is not the knowledge of facts which makes a man educated, but the possession of method. To teach a man to learn how to learn is the true function of education, and to stuff his mind with facts beyond this point is merely to encumber him in pursuing his means of livelihood. It is true that the method of education adopted may, and perhaps should, bear some relation to ultimate ends. The future classical scholar will save himself much annoyance by a diligent study of Greek irregular verbs. The future mechanical or electrical engineer will enjoy an

ease, not otherwise procurable, by a thorough mastery of elementary mathematics. But, still, education is not so much intended for the elucidation of old problems as for the tackling of those that are new. And, as a knowledge of facts without the power of ratiocination is worthless for new ventures, and as every problem which meets us in life is a new venture, therefore, method by itself is everything, and facts by themselves are nothing.

The faults of technical education of the present day are that they tend to reproduce a microcosm of real life. Everyone has heard of, or has seen, a typical specimen of the "tank drama," in which there is real water, real horses, a real fire engine, or what not, to heighten the verisimilitude. The technical colleges which attempt to make a blacksmith or a mechanic out of a student, fail, just as the "tank dramas" do, by endeavoring to make their courses a miniature copy of future work instead of making them typical of crises and illustrative of principles. Let us glance for a moment at the two great professions where education, as commonly understood, utterly fails to supply a man with the power of commanding success. It will be acknowledged that painting is an art which requires initiation and instruction. Yet, without genius, without inspiration, even the most skilful painters have been unable to rise above the ranks of mediocrity. The Italians call Andrea del Sarto "the faultless painter." But, as Symonds says, he lacked inspiration, depth of emotion, energy of thought, and cannot therefore take rank among the great Renaissance painters. Or take again the two typical cases of the Archduke Charles and Major General Halleck, for

both of whom it may be claimed they were bright and shining examples of profound technical education in the military art. The genius of Napoleon, not a particularly distinguished student, overthrew with ease the strategy of the Archduke Charles, while all that Halleck's technical knowledge seemed to be able to do for him was to point out every possibility of defeat without inspiring him to a single means of victory. More recently we have seen Sir John French, the only really successful cavalry general of the South African War, overthrow in the field the reputation which the pedants of Aldershot gave him of not being able to handle a cavalry brigade.

We may gather from these examples, and from others which will occur to the minds of every one, that all that technical education can do is to give each man his chance of success or failure. Genius may be able to dispense altogether with technical education; inherent stupidity will ultimately sink to its true level, in spite of the most careful collegiate training. In considering educational matters, therefore, we are concerned not with geniuses or with muddle-heads, but with average men. How the average man may be trained for a profession for which he feels within himself some aptitude is the question which it behooves us to answer. And the answer which we should give, is to teach methods, to instill principles, to lay deep and sure the foundation of elementary knowledge, and trust the future to take care of itself. We have, therefore, two correlated branches of education to consider—education as an art and education as a science.

Education as an art involves perfect familiarity with

a larger or smaller number of facts, according to the purpose to which these are to be devoted. In this age of universal reading and writing we are apt somewhat too hastily to assume that a categorical knowledge of the alphabet and the arithmetical tables is necessary to success in life. Those who have lived in countries where a considerable portion of the population is wholly illiterate must have often been struck by hearing men who could not read, use language all but grammatically correct, or by observing intricate accounts made up by mental arithmetic without the aid of either multiplication or division. It must also be remembered that in the Dark Ages kings and bards were usually illiterate, though they were none the less the rulers and inspirers of their times. Education as an art, therefore, must be separated from personality on the one hand and from mere pedantry on the other. We may compare education as an art to a knowledge of the names and functions of the pieces on a chessboard, divorced from any knowledge of the game of chess itself. If we can then imagine a series of chessboards, each having more pieces than the one preceding it, and each set of pieces having more complex moves than the set preceding it, we shall have a fair analogy of the gamut of education as an art, from simple elementary education to the highest classical or mathematical standard. Throughout this series there are things to be known by name—what may be called primary concepts—and these mere names have to be clothed with ideas or attributes or functions, by means of which we may see how far we can utilize them. In other words, in education as an art we have to exercise the faculty of memory, and this memory

must be clear and accurate if our minds are always to have their tools at hand, ready for instant use. But this in turn implies familiarity and familiarity implies constant practice for a longer or shorter time. Here again our average education for the average man comes in. If we have in mind only the first twenty-five per cent. of our pupils—the geniuses and the hard-reading men—we shall pass along to the next stage before our fifty per cent. of average men have had time to become perfectly familiar with the facts and their connotations which are being studied. If, on the other hand, we attempt to wait until the last twenty-five per cent. of our pupils—the incorrigibly idle and muddle-heads—we shall waste the time of our fifty per cent. of average men. In every stage of education as an art we have, therefore, two things to consider, namely, the accumulation of a sufficient number of names and their connotations to give us an ample nomenclature or set of tools, and also enough familiarity with this nomenclature or set of tools to enable us instinctively to select the right tool and to use it efficiently.

Let us now pass to education as a science. A man might know the dictionary from end to end, and yet not be able to use more than one thousand words of it for any particular purpose. Having obtained our tools through education as an art, the problem in education as a science is not to use them as we have been taught, but to apply them to new problems. To go back to our former illustration we must be able to play the game of chess after having learned the names of the pieces and their functions. It took the world two thousand years to find out that deductive logic could state noth-

ing new beyond what was contained in the premises. Science, we are told, is organized and classified knowledge, and the first thing a truly educated man will do with a new fact is to place it under its proper classification—that is, he will refer it to the principle which governs facts of a similar kind. Not only, therefore, is memory needed here, but imagination. A man's whole education goes for nothing if in dealing with a new fact he cannot see resemblances in it to other facts where none outwardly exist, or cannot see profound differences between a new fact and an old one where the outward resemblance is strong. And the highest function of education as a science is to make a man of average ability see resemblances and differences in cases where he would otherwise be blind. Indeed, genius itself, as we see it in the great inventors, is usually nothing more than the power of classifying a fact under its proper generalization and then re-stating it in terms of some other fact classed under the same head.

Rising stage by stage, therefore, according to the future for which our educational requirements are to fit us is our elementary knowledge plus perfect familiarity in dealing with and handling it. Better, far better, that we should know little but be on terms of perfect familiarity with that little, than we should know much and have to grope for what should spring to our minds as quick as thought itself. The time spent, the labor involved, in obtaining an absolute mastery over our primary concepts or elementary knowledge marks the difference in our future work between having strange tools to handle and having tools which so fit into our hands as to become an inseparable part of ourselves.

Let us turn now to the education of an engineer. The definition of an engineer, according to Brunel, is one who applies the forces of nature to the service of man. Mr. Mansergh, recently President of the Institution of Civil Engineers, quoted with approval an American definition of an engineer as "a man who could do for one dollar what any fool could do for two dollars." Perhaps the best definition will lie somewhere between these extremes. If a man does not know how to apply at least one form of the forces of nature to the service of man he is not an engineer; and if he cannot do this more economically than an outsider no capitalist with common sense will employ him. An engineer differs from a physician or a lawyer in that patients die and cases are lost without damaging the reputation of a member of either of these professions; while, on the other hand, an engineer's work must speak for itself. The motto over Sir Christopher Wren's tomb in St. Paul's might be adopted as that of the engineering profession as a whole, "*Si monumentum requiris circumspice.*" Posterity camps on the trail of the engineer, and its conclusions, like the judgments of the Lord, are true and righteous altogether. Whether it be the aqueduct of Rome or the Brooklyn Bridge, whether it be a generator at Niagara Falls or the switchboard of a New York power station, it will either form a model from which other generations of engineers will expand into new conceptions to meet new needs, or it will become a beacon post to point out the way which is to be avoided. Verily, it is no light thing to train up an artist in the forces of nature!

Let us begin with the prime essential. Without

reverence for great works and for the great men by whose agency they were brought forth, there will be no great engineers. Granted that, a sound knowledge of one's native tongue is the best substructure. The great engineers who have been deprived of this aid, have borne eloquent testimony by their efforts at self-improvement in later life to what they considered would have been its usefulness at an earlier period of their careers. An elementary knowledge of Latin is almost indispensable to the clarification and consolidation of the knowledge of nearly every European tongue. Next to these my vote would go to a good working knowledge of French, because besides its obvious advantage as a language to be spoken, it imparts lucidity and precision to writing—a thing, by the way, which mathematics often fails to do. Early practice in mechanical drawing should also be given to every boy who feels within himself the stirrings to become an engineer, because familiarity with the pencil is easily acquired early in life, but is often one of the greatest stumbling blocks when taken up too late.

Then as to mathematics. As the profession of an engineer always involves constant dealing with quantities and values, he ought to know mathematics as he knows the currency of his native country. In other words, he ought to be able to make change with ease, quickness, and accuracy—not as if one were in a foreign country in a constant state of painful reckoning. A thorough knowledge of ordinary mathematics is here prescribed, not any vain ascents with crippled wings into the empyrean. What is meant by "ordinary mathematics" may perhaps be more clearly indicated

by a remark and an anecdote. One may make accurate change without any knowledge of the science of numbers. Lord Salisbury, when President of the British Association, told the story of the Oxford Professor who said to him, fiercely, "What I like about quaternions, Sir, is that they cannot be used for any base utilitarian purpose."

This makes our substructure complete. The first part of our superstructure should consist in learning the principles of the applied sciences. These should be studied in books, assisted by oral teaching, and enforced and reënforced by the practice of dozens or hundreds of examples. If one wants to know how each principle should be learned, he should watch a great singing teacher train a pupil. A false note in a scale demands a hundred perfect repetitions. A false note in an *aria* means back to the scale for a hundred more repetitions before attacking the *aria* a second time. Why should the future artist in nature be less carefully prepared for his work? Is that work likely to be less important? Or is it merely because his future audience is less likely to detect a false note?

With this, the education of our engineer ends or rather begins. He may be fifteen, sixteen, or any age. He may have studied in school, or in college, or at home. He is, however, a trained engineering soul, according to the measure of his talents. He is able to learn the art of engineering, or any other art, for which he has an aptitude, in months, where another man of equal ability might take years and not know it half so thoroughly. All he needs to ensure his success in life is to find a master who can utilize his powers.

ENGINEERING ENGLISH.

BY T. J. JOHNSTON.

This paper is a corollary of the discussion at Great Barrington last summer, and refers to only one subject which should be included in the curriculum of an engineering education; that is, the English language.

It should be self-evident that the first preparation of the engineer for his profession is to acquire a knowledge of his vernacular, the "first tool of the mind." It has been well said that one who thinks clearly can speak clearly; in fact, we cannot know that the man's thought is clear until he expresses it so that we, having regard to our own limitations, can understand it. That this is true will be borne in upon anyone who is required to consult engineers about what has happened at particular dates. Everyone knows the difficulty of proving precisely the events of the long ago; but here I do not refer to the fallibility of the memory, but to the mere expression of ideas. It is a common thing that no two engineers describing the same phenomenon will give anything like the same description, and this is due not to their want of knowledge of the phenomenon, but to the inaccuracy of their language. That I am not alone in this view is evident from the expressions of competent authorities; I may instance an article of Professor H. W. Wiley in *Science* for November 28, 1902, page 845, where he says:

"I have often been mortified at the English composition of college and even university graduates. Men

who have attained eminence in particular branches of study often seem incapable of expressing their thoughts in any proper way. Their English is inexact, clumsy, and inconsequent. Clear expression seems to me to be the legitimate outcome of clear thinking, and the neglect of those early studies which enable one to express himself clearly and forcibly is a fault which can only be remedied by long years of mortification and hard labor."

I also cite the address of Professor John Perry, to which Mr. Mailloux referred in the Great Barrington discussion.

"Only one subject—Latin—is really education in our schools. I do not mean that the average boy reads any Latin author after he leaves school, or knows any Latin at all ten years after he leaves school. I do not mean that his Latin helps him even slightly in learning any modern language, for he is always found to be ludicrously ignorant of French or German, even after an elaborate course of instruction in these languages. I do not mean that his Latin helps him in studying English, for he can hardly write a sentence without error. I do not mean that it makes him fond of literature, for of ancient literature or history he never has any knowledge except that Cæsar wrote a book for the third form, and on English literature his mind is a blank. . . .

"I ask for a return to simplicity of system. English (the King's English; I exclude Johnsonese) is probably the richest, the most complex language, the one most worthy of philologic study; English literature is certainly more valuable than any ancient or modern

literature of any one other country, yet admiration for it among learned Englishmen is wonderfully mixed with patronage and even contempt.

"Well-equipped schools of applied science are getting to be numerous, but I am sorry to say that only a few of the men who leave them every year are really likely to become good engineers. The most important reason for this is that the students who enter them come usually from the public schools; they cannot write English; they know nothing of English subjects; they do not care to read anything except the sporting news in the daily papers; they cannot compute; they know nothing of natural science; in fact, they are quite deficient in that kind of general education which every man ought to have."

I do not mean by this criticism that engineers should spend long periods in learning the grammatical and rhetorical construction of the language; but I do mean that English composition should be kept up in engineering schools and that engineers should be drilled in the use of English until they can express with entire accuracy the meanings which they so often commit to formulæ. Pick up any engineering article, and one may rarely read a page without some blunder appearing which spoils the sense either by not saying what the engineer means or by saying what he does not mean.

"Have something to say, and say it," was the Duke of Wellington's theory of style; Huxley's was "to say that which has to be said in such language that you can stand cross-examination on each word." This is the secret of his lucidity.

To show how far from the criteria of style of either

the "Iron Duke" or Mr. Huxley our engineers are, I quote a few examples of engineering English.

"Generator dissembled."

"More customers, cheaper the cost of production."

"Formerly the slag of steel works was considered purely a dead waste, but some few years ago its valuable fertilizing value was discovered, and now this formerly valueless waste is one of the world's most valued fertilizers."

"Such schemes as M. ———'s is not a solution."

"A body like you propose."

Of certain generators, it was said they "can not be run in parallel."

"This operation is to be operated at every station."

"In a shaft eight thousand feet deep the cost of *cooling the temperature* would be considerable."

"How much we have had to pay because of the slow speed."

"Details as to *how small* turbines could be manufactured."

"Encourages attack upon the doctrine of the right . . . to control their business. . . .

"This discharge took place perfectly regular."

"There is no reversing plugs."

"For which the unenviable distinction of being the worst in the world is often claimed for it."

"To this was added two . . . generators."

"Gas-engine would develop along the same lines as the steam-engine had done."

"The low height of the turbine permitted a reduction of the height of the engine room."

"The correctness of my conclusions have been amply demonstrated."

"This can be done equally as well with the motor at no load as at full load."

"Four motors . . . will perform a faster schedule."

"An almost infinitestimable amount."

"The last two thirds" (of a commutator brush).

"The matter of convenience . . . is shown in every detail."

"Brackets cast solidly with frame."

"The rings . . . are circular in shape."

"One and the same motor."

"The car is well lit."

"Not only sécuring pole (pole-piece) but also of drawing same down to the tightest of magnetic contacts."

"The cost of superimposing a second floor on the present system would cost as much as the original cost of building the present system."

"The company find it impossible to buy only at retail prices."

"Which renders great economy and rapid construction."

"The three top voltages were the . . . ones . . . used."

"Trains can run at fast speed."

"The hollow of both electrodes communicate with the open air, and when in contact form an air-tight joint."

"Their errors" (of electrical measuring instruments), "were determined by taking them to the works of the Weston Co."

"Continued to do good work when pronounced as ruined."

"We do not think present conditions demand."

"A fewer number will perform a given amount of work four times as long as any other cell of equal size."

"There is no question but that."

"It would have been better to have had."

"Why does a cell constant change when the density of the solutions change?"

"The lapse of time which are here chiefly in question."

"Not yet fully decisive."

"The correct solution for the problem of cause has been discovered."

These (about five per cent. of those I have seen) have been gleaned since the Great Barrington discussion, from reports of engineers, descriptions of operations furnished to engineering periodicals by engineers in charge, and, "woe is me," from letters to the technical press written by professors of applied physics in universities! I regret to say that some of the most glaring solecisms are from the last-named source.

Wendell Phillips once said that there are only thirty-seven jokes in all languages, but Mr. Phillips died before electrical engineers had written much.

It is only necessary to refer briefly to the inaccuracy of terms common in the profession, and particularly to double meanings applied to well-known words which should be terms of precision. "Static transformer," when stationary transformer is mean; the "capacity" of a system, when the maximum output is mean; the "field" of a generator, when the field-magnet is meant, are common examples of the appropriation of a well-known term to a new use, generally inaccurate. "The

time would fail me" to do more than shake hands with our old enemies. "Equally as well," "the two highest," "one and the same," *et id omne genus.*

I see many mining engineers in the course of the year. Respectable vagrants as they are, their correct and often elegant diction is a surprise and a pleasure, and somewhat of a reproach to our own members; though a mining engineer, to be sure, would have but a dry practice if he could not furnish the materials for a good prospectus.

This is no protest against the study of languages other than English. *Per contra,* just as no man can be a sound mathematician who confines his study to algebra or trigonometry, so no man can learn English thoroughly without some comprehension of its sources in other languages. The true meaning of a word can only be learned by learning its root, and from that its trunks and branches are easily understood.

Let no man say "I am too old to take up such studies; they were neglected in my youth, and I am as I am." Caleb Cushing, Attorney-General of the United States, statesman, diplomat, and jurist, learned in literature and science, began the study of French when he was seventy years of age. The subsequent proceedings are not generally referred to; but having heard Mr. Cushing's French, I may add that although public safety prohibited his pronunciation, his knowledge of the shades of meaning of the spoken language would have shamed many English-speaking persons long resident in France.

Most of the errors in Engineering English are due to want of attention; few engineers revise the language

of their reports and articles as they do the tables and formulæ upon which the text is based; fewer still, even in important investigations, think it worth while to have the text read by another to detect errors.

I may quote from President Woodrow Wilson's inaugural his unanswerable plea for a liberal education, as a special plea for adequate instruction in English, either as a preparation for, or better still, for both that and a part of an engineering course.

"No doubt the old, purely literary training made too much of the development of mere taste, mere delicacy of perception, but our modern training makes too little. We pity the young child who, ere its physical life has come to maturity, is put to some task which will dwarf and narrow it into a mere mechanic tool. We know that it needs first its free years in the sunlight and fresh air, its irresponsible youth. And yet we do not hesitate to deny to the young mind its irresponsible years of mere development in the free air of general studies.

"What we seek in education is a full liberation of the faculties, and the man who has not some surplus of thought and energy to expend outside the narrow circle of his own task and interest is a dwarfed, uneducated man. We judge the range and excellence of every man's abilities by their play outside the task by which he earns his livelihood. Does he merely work, or does he also look abroad and plan? Does he, at least, enlarge the thing he handles? No task, rightly done, is truly private. It is part of the world's work.

"A merely literary education, got out of books and old literature, is a poor thing enough if the teacher stick at grammatical and syntactical drill.

"It is not the education that concentrates that is to be dreaded, but the education that narrows—that is narrow from the first."

Do we not all assume too readily that because we speak, or think we speak, English, our expression of the thought in our minds is impeccable? Is not our vocabulary too strictly professional? Does it not cramp the intelligence and impair perception? Ought we not to "break their bonds asunder," and learn thoroughly to use the master-tool—English?

President Scott.—One of the speakers said that an engineer ought not to be judged until he had been in practical experience for, say, twenty-five years. If you set that standard, then, we cannot begin to receive a verdict on the modern electrical engineer for ten or fifteen years to come. The modern electrical engineer is a new engineer. He has a new kind of work. The census shows that electrical work as represented by the capital invested, increases something like twenty per cent. a year. Men are needed rapidly and the followers of engineering, and particularly of electrical engineering, have as their principal function in the world, increasing the efficiency, the effectiveness, of modern life; so it behooves these two societies which are represented here to-day to unite and to expand every effort for the more thorough production of efficient engineers.

President Woodward.—Mr. President, I would like to call upon the Secretary of the Society for the Promotion of Engineering Education to present to this meeting some action that the Society took at its last meeting by itself.

Secretary Waldo of the Society for the Promotion of Engineering Education, read the folowing:

"Moved, that the thanks of this Society be extended to the American Institute of Electrical Engineers for the excellent arrangements made for our meetings, for excursions and for our general comfort and entertainment, and for the general spirit of hospitality of which we have been especially conscious, and that this vote also be extended particularly to the members of the General Committee and to the Local Committee of the Institute."

President Scott.—On behalf of the Institute I express our appreciation of the resolutions which have been presented, and reiterate the sentiment I expressed a moment ago, namely, that the Institute deems one of its important functions in the engineering profession, the promotion of the education of the electrical engineer, the same work that is represented by your Society.

President Woodward.—I think, Mr. President, I can safely say that at some future time the Society will be very glad to meet with you again; not next year perhaps, or the year after, but in the near future. This has been so profitable I think to all of us college men that we shall be glad at some future day, when we all become wiser men and better engineers, to compare results once more.

President Scott.—And it is our hope that the time may not be even so long extended as you suggest.

Mr. Weeks.—If it be not understood that the able paper by Professor Jackson will be printed as part of

the transactions of the American Institute of Electrical Engineers, I would like to move that it be so arranged. I should be very sorry to have that left out of the series in our discussions.

This motion was carried and the joint session adjourned.

ESTEVAN ANTONIO FUERTES,

Died January 16, 1903.*

Professor Fuertes was born at San Juan, Porto Rico, May 10, 1838. He had excellent educational facilities. His primary education was received at home, and his secondary at the Concillar College of San Ildefonso, Salamanca, Spain, where he received both the degree of Ph.B. and that of Ph.D. He then came to the United States and graduated from the Rensselaer Polytechnic Institute, Troy, N. Y., in 1861 with the degree of C.E.

Upon his return to Porto Rico he was connected with the Department of Public Works for two years, first as an assistant engineer, and later as Director of the Western District.

In 1863, he came to New York and obtained a position as assistant engineer under the Croton Aqueduct Board and was assigned to the collection department. Loose methods of estimating the water used by large consumers were in use, and he began a careful study of the manufacturing plants and of the manufacturing processes to determine the amount of water necessary for a given product, and exercised constant watchfulness to make sure that none of the processes and none of the product were concealed. Under his efficient management the revenues of the department were largely increased, while his fairness and good judgment won the respect of those most affected by the change. Upon Tweed's accession to power he was given the option of becoming a tool for the ring or of resigning. He chose the latter and withdrew in 1869.

He opened an office in New York, and soon had a lucrative consulting engineering practice which was given up in 1873. In 1870, he was Engineer in Chief of an expedition sent out by the United States Government to study the feasibility of a ship canal across the isthmus of Tehuantepec.

He had always been deeply interested in technical education and in securing for civil engineering in this country, the rank of a learned profession as in Europe. Accordingly, when the opportunity was presented of coming to Cornell to take charge of the work in civil engineering, he was ready to leave good consulting practice in New York and devote his life work to the cause of technical education. He brought to the work enthusiasm and a

* Memoir prepared by Professor Charles L. Crandall.

thorough appreciation of the needs of the profession. His first efforts were for the improvement and enlargement of the technical portion of the work; later, as opportunity offered, he was ready to extend the general education by increased entrance requirements, by modifications of the course and by encouraging students to first graduate in arts. He believed in the use of graphic methods of illustration, of models and practical problems, in fixing and illustrating principles and connecting them with actual practice. He was among the first to advocate laboratory work for civil engineering students.

He was a firm believer in the broadening influences which the technical student receives from contact with the university, as compared with the student in the isolated technical college, but he always looked with distrust upon the control exercised over the technical work by the general faculty. On this account he was an earnest advocate of the college system, which has since been adopted, where each department or college is placed under the management of its own faculty, except in matters pertaining to general university policy.

Under the stress of work, care, and anxiety, his health began to fail, and during the year 1892–3 he was given a year of well-earned rest in Europe. He spent the winter in Italy, but was soon at work upon the sanitation of Santos, Brazil, which at that time was having an epidemic of yellow fever. He returned by way of Santos, in order to collect data for the work, and with Rudolf Hering, designed a very complete system of sanitation, including sewers, quarantine buildings, etc. The compensation received was liberal, and ever mindful of the university, he founded two medals of the value of $50 each, one for undergraduates, the other for alumni. He also provided for the endowment of a Professorship of Sanitary Engineering to take effect at the time of his death if his estate remained intact.

With improved health university duties were resumed with zeal, the number of students increased rapidly, and the department developed into a college, with increased duties and responsibilities and a separate faculty. During this period of rapid growth there was much work and many cares and anxieties, and his health again began to fail. Treatment in New York during the spring of 1900 gave temporary relief, but the difficulty had developed into chronic Bright's disease and strength did not return. His resignation as Director and Dean of the College was announced November 7, 1902.

The Board of Trustees, in accepting his resignation, expressed grateful appreciative recognition of his long and faithful service, his self-sacrificing devotion, and his marked ability as Director of the Department and College of Civil Engineering. He was appointed Professor of Astronomy in charge of the Barnes Observatory. He took charge of the completion of the building and engaged in consulting work. He died January 16, after an illness of only a few days.

Professor Fuertes was well known both in this country and abroad, and thoroughly appreciated as a gentleman and as an engineer; he was warm-hearted and sympathetic and had many friends. He was a member of the American Society of Civil Engineers; the Societé d'Ingenieurs, of France; the Royal Economic Society of Spain; the Humboldt Society, and the Society of Geography and Statistics of Mexico. He was elected a director of the American Society of Civil Engineers. He was decorated by the Spanish government for professional services.

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